GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. E-26-623

DATE 3/10/82

Project Director: J. L. Carden

School/~~Lab~~ Nuclear Engr.

Sponsor: National Institute for Occupational Safety and Health

Type Agreement: Purchase Order No. 82-1698

Award Period: From 2/26/82 To ~~6/26/82~~ 10/31/82 (Performance) ______ (Reports)

Sponsor Amount: $4,950

Contracted through: GTRI/~~GIT~~

Cost Sharing: none

Title: Integration of Occupational Safety and Health Training into the Engineering Curriculum

ADMINISTRATIVE DATA

OCA Contact William F. Brown x4820

1) Sponsor Technical Contact:

Mr. John Talty, Project Officer
(same as Mr. Hufnagel)

(513) 684-8241

2) Sponsor Admin/Contractual Matters:

Mr. Carl Hufnagel, Contracting Off.
Nat'l Inst. for Occupational Safety & Healt
Robert A. Taft Labs
4676 Columbia Parkway
Cincinnati, OH 45226
(513) 684-8217

Defense Priority Rating: none

Security Classification: none

RESTRICTIONS

See Attached ______ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed or anticipated

COMMENTS:

Project Director shall notify Grants and Contract Accounting when each task is complete and accepted for billing purposes.

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Other ______

FORM OCA 4:781

GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 3/1/83

Project Title: Integration of Occupational Safety and Health Training into the Engineering Curriculum

Project No: E-26-623

Project Director: J. L. Carden

Sponsor: National Institute for Occupational Safety and Health.

Effective Termination Date: 10/31/82

Clearance of Accounting Charges: 10/31/82

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice ~~and Closing Documents~~
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other ______________________

Assigned to: Nuclear Engineering (School/Laboratory)

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FORM OCA 10:781

E-26-623

Occupational Safety and Health Training in the Engineering College at Georgia Tech

A Progress Report

Submitted to:

The Training and Manpower Development Division
of the National Institute for Occupational
Safety and Health
Purchase Order Number: 82-1698
Project Monitor: Mr. John Talty

Submitted by:

The School of Nuclear Engineering and Health Physics
Author: Dr. John Carden

Occupational Safety and Health Training

in the Engineering College at Georgia Tech

1.0 Introduction

During August, 1982, a survey of faculty members and administrators of the College of Engineering was carried out. The survey consisted of personal interviews performed by the author. The following information was sought during the interview:

1. Occupational Safety and Health (OS&H) topics of particular relevance to the discipline of the interviewee.
2. The present degree of coverage of important OS&H topics in the interviewee's school
3. courses currently in the curriculum with potential for inclusion of OS&H information.
4. Insight into the past and current problems with inclusion of OS&H information into the school's curriculum
5. An evaluation of the value and potential for success of a college wide video based modular course providing an introduction to OS&H concepts, issues and materials.
6. Other suggestions for the delivery of OS&H training within the interviewee's school.

The information obtained on each of these questions is presented in the section which follows. Potential scenerios for increasing under-graduate exposure to OS&H training are presented in the final section.

2.0 Results from Interviews

2.1 Background

The eleven degree granting schools making up the College of Engineering at Georgia Tech are listed in Table 1 along with their percentage of the undergraduate population during Fall Quarter 1981. The total undergraduate engineering enrollment during that quarter was 6,580 students.

A summary, taken from the 1982-83 General Catalogue, of the undergraduate program of each school including the undergraduate curriculum is included in Appendix 1. It should be noted that Nuclear Engineering also offers an undergraduate degree in health physics and Textile Engineering offers degrees in textile chemistry and textiles. Thus, the College has a total of 14 programs offering Bachelor's degrees.

School	Percentage of Engineering College Enrollment (Fall 1981)
Aerospace Engineering	8.4
Ceramic Engineering	0.7
Chemical Engineering	12.9
Civil Engineering	8.5
Electrical Engineering	27.2
Engineering Science and Mechanics	1.4
Health Systems	1.0
Industrial and Systems Engineering	11.8
Mechanical Engineering	20.1
Nuclear Engineering	2.0
Textile Engineering	1.3
Undecided (freshmen)	4.8

Table 1. The degree granting schools making up the Engineering College at Georgia Tech and the percentage of undergraduate students enrolled.

Interviewees were chosen based on the author's awareness of interest in OS&H, a recommendation from the Associate Dean of Engineering, a recommendation by another faculty member, or the research and academic interest of a faculty member as indicated in the "Register of Professional Personnel of the College of Engineering." Seventeen teaching faculty members were interviewed in person and two were interviewed by phone.

2.2 Discipline Specific OS&H Topics

For the purpose of this study it seems reasonable to divide OS&H topics or skills into two groups; those of direct professional importance and those of general importance. Direct professional importance covers those topics and skills which a graduate engineer might reasonably be expected to have mastered in sufficient depth to be able to solve an OS&H problem. For instance, a mechanical engineer could reasonably be expected to be able to design an industrial ventilation system, thus industrial ventilation is a topic of direct professional importance in mechanial engineering. General importance covers those topics and skills to which an engineer needs to be introduced to create awareness, but generally involves problems which the engineer himself/herself would not be expected to solve. For example, an industrial engineer might note a probable noise exposure problem in a production area, but he would likely request an evaluation by an industrial hygienist and look for a solution from a mechanical engineer.

In order to deal in a uniform way with the potential problem of a faculty member being essentially unaware of OS&H aspects of his discipline, a list of typical topics was generated (see Table 2) and taken to each interview. The list was not shown to the interviewee and was only used when necessary to stimulate thinking along appropriate lines.

The results of this portion of the study are presented school by school in the material that follows.

1. Common Industrial illnesses
2. Ergonomics and human factors
3. Heat stress
4. Noise and vibration
5. Nonionizing radiation
6. Ionizing radiation
7. Lighting and illumination
8. Ventilation
9. Personal protective devices
10. Applied industrial toxicology
11. Environmental monitoring
12. Sanitation
13. OS&H literature
14. Sources of services and assistance
15. Legislative and regulatory requirements
16. OS&H program structure and management
17. OS&H program costs and payback
18. Facility layout and materials handling
19. Emissions control
20. Fire and life safety

Table 2. Typical OS&H topics.

One or two faculty members were interviewed in each school, thus the ideas and conclusions reported could reflect uncompensated personal bias. Never-the-less the information obtained seems adequate for the overall purpose of this study.

2.2.1 Aerospace Engineering (AE)

One faculty member from this school was interviewed. He indicated that the technical area generally dominated by AE graduates is air frame design. Areas shared with other disciplines include engine design and control system layout and design. It was not clear that any major professional responsibilities for OS&H exist for AE's, but there are a number of general areas of importance including shop safety, noise, vibration, human factors, heat stress, ionizing radiation and nonionizing radiation.

2.2.2 Ceramic Engineering (CERE)

One faculty member from this school was interviewed. Bachelors level graduates from this school are involved in all aspects of the glass and ceramics industry. Professional interests identified include heat stress, noise and vibration, ventilation, personal protective devices and legislative and regulatory requirements. General interests identified include common industrial illnesses, OS&H program costs and paybacks, nonionizing and ionizing radiation, lighting and illumination, industrial safety, applied industrial toxicology, OS&H program structure and management, sources of services and assistance, and environmental monitoring.

2.2.3 Chemical Engineering (ChE)

Two faculty members from this school were interviewed. Typically ChE's are found in a wide range of positions in the chemical process industries from process development and design to operations and manage ment. Areas of direct professional importance include facility layout, environmental monitoring, and emissions control. All of the topics in Table 2 are of general importance because of the high probability of operations or management responsibilities.

2.2.4 Civil Engineering (CE)

Two faculty members from this school were interviewed. The Bachelors program in CE provides training for specialization in a broad spectrum of area spanning structures and construction to environmental engineering, surveying, soil mechanics, hydrology and transporation. The wide range of potential activities of graduates makes identification of specific major professional responsibilities difficult. The following general responsibilities were identified: common industrial illnesses, ergonomics, heat stress, noise and vibration, nonionizing radiation, ionizing radiation, personal protective devices, applied industrial toxicology, sanitation, environmental monitoring, OS&H program structure and management, and legislative and regulatory requirements.

2.2.5 Electrical Engineering (EE)

Two faculty members from this school were interviewed. The undergraduate EE program covers a number of areas with approximately 70% of our students currently specializing in some area of digital electronics which probably will not lead them into equipment design or device fabrication. It is felt that these students do not require any training in OS&H. The remaining 30% specialize in areas such as physical electronics and power engineering with associated risk of exposure to occupational hazards. Major professional responsibilities were not identified, but general responsibilities include heat stress, noise and vibration, nonionizing radiation lighting and illumination, ventilation, personal protective devices, applied industrial toxicology, and legislative and regulatory requirements.

2.2.6 Engineering Science and Mechanics (ESM).

Two faculty members from this school were interviewed. ESM emphasizes the fundamentals underlying engineering practice and as a result graduates of this school are often involved in the development of processes or equipment for which no design criteria exists. Major professional responsibilities may include human factors and noise and vibration while general responsibilities may include nonionizing radition, ionizing radiation, lighting, illumination, ventilation, applied industrial toxicology and legislative and regulatory requirements.

2.2.7 Health Systems (HS)

One faculty member from this school was interviewed. HS prepares students for the planning and operation of health care delivery systems. While no major professional responsibilities were identified, the general responsibilities associated with operations and management could involve any of topics covered in Table 2.

2.2.8 Industrial and Systems Enginering (ISyE)

One faculty member from this school was interviewed. Bachelors level graduates from this school are involved in a wide range of operations oriented activities. Major professional interests identified include ergonomics and human factors, industrial safety, OS&H program structure and management, and the providing of services and assistance with some OS&H related problems. General interest include common industrial illnesses, OS&H program costs and paybacks, heat stress, noise and vibration, lighting and illumination, ventilation and personal protective devices.

2.2.9 Mechanical Engineering (ME)

Two faculty members from this school were interviewed. Major professional areas identified include ergonomics, human factors, noise, vibration and ventilation. General responsibilities may involve all of the topics of Table 2 with the exception of sanitation

2.2.10 Nuclear Engineering and Health Physics (NEHP)

One nuclear engineering faculty member was interviewed and the author contributed input regarding health physics. Nuclear engineering contributes heavily to the design and operation of nuclear power generating facilities and the facilities associated with nuclear fuel cycles. Health Physics provides expertise in interactions between ionizing radiation and various materials (human or otherwise). Both NE and HP graduates have a professional interest in ionizing radiation and personal protective devices. NE graduates are likely to have a general requirement for information concering heat stress, noise and vibration, ventilation, applied industrial toxicology and fire and life safety. HP graduates are at times called upon to provide some basic industrial hygiene services, thus all of the topics in Table 2 are at least of several interest.

2.2.11 Textile Engineering (TEX)

Two faculty members from this school were interviewed. This school offers undergraduate programs in three areas; textile engineering, textile chemistry, and textiles. Familiarity with OS&H regulatory requirements was identified as a major professional responsibility and all of the topics in Table 2 were identified as probable general responsibility. Air borne particulates such as cotton dust is another issue identified as particularly important to TEX graduates.

2.2.12 Summary of Issues Identifed

Table 3 lists the topics identified as relevant to their discipline by the faculty members interviewed.

TOPICS	SCHOOL										
	AE	CERE	ChE	CE	EE	ESM	HS	ISyE	ME	NE	TEX
Common industrial illness		G	G	G			G	G	G	G	G
Ergonomics and human factors	G		G	G		P	G	P	P	G	G
Heat stress	G	P	G	G	G		G	G	G	G	G
Noise and vibration	G	P	G	G	G	P	G	G	P	G	G
Nonionizing radiation	G	G	G	G	G	G	G		G	G	G
Ionizing radiation	G	G	G	G		G	G		G	P	G
Lighting and illumination		G	G		G	G	G	G	G	G	G
Ventilation		P	G		G	G	G	G	P	G	G
Personal protective devices		P	G	G	G		G	G	G	P	G
Applied industrial toxicology		G	G	G	G	G	G		G	G	G
Environmental monitoring		G	P	G			G		G	G	G
Sanitation			G	G			G			G	G
OS&H literature			G				G		G	G	G
Sources of services and assistance		G	G				G	G	G	G	G
Legislative and regulatory requirements		P	G	G	G	G	G		G	G	P
OS&H program structure and management		G	G	G		P	G		G	G	G
OS&H program costs and payback		G	G			G	G		G	G	G
Facility layout and materials handling			P				G		G	G	G
Emissions control			P				G		G	G	G
Fire and life safety		G	G			P	G		G	G	G
Shop safety*	G										
Airborne particulates*											P

Table 3. Topics identified by interviewees as important to students in their school. P denotes professional importance, G denotes general importance.

* identified by school indicated

2.3. Current Coverage of OS&H Topics

Prior to the interviews the course descriptions given in the 1982-83 General Catalogue were searched to identify courses which might contain or appeared to have a potentital for inclusion of OS&H topics. The courses falling into this category are listed, along with the catalogue description, in Appendix 2. This material was used as the starting point for discussion during the interviews.

2.3.1 Aerospace Engineering

Two undergraduate (AE 4760 and 4761) and four graduate courses (AE 6760, AE 6761, AE 6762, AE 6763) in accoustics are multiply listed in this school as well as in ESM and ME. The first two courses are senior electives. Undergraduates are not generally allowed to take the upper level (6000) courses. the 4000 level courses have not been taught recently because of demands on the faculty to teach other courses in the curriculum. The 600 level courses have not been offered for the past three years for the same reson. the OS&H relatd training currently provided in this school is generally restricted to information given to students prior to performance of exercises assigned in teaching laboratories. The school's shop, which is used by students as well as professionals, has an established training and "check out" system which emphasizes safety.

2.3.2 Ceramic Engineering

Some OS&H information is provided at relevant places in existing courses. Examples include a discussion of the hazard associated with respirable α-quartz as a part of glass compounding and a discussion of As_2O_3 exposure during bubble removal. Personal protective devices and safe practices are discussed as a part of teaching laboratory preparation and prior to plant visits. Ventilation and air handling is stressed because of its importance in ceramics production. The general philosophy associated with OS&H training emphasizes the practical i.e., adequate worker protection must be provided in an economically acceptable manner.

2.3.3 Chemical Engineering

ChE 4414 ("Air Pollution Control") apparently does not contain material directly related to OS&H. ChE 67613 does include a short discussion of the effects of particle size on deposition in the air ways of the respiratory system.

2.3.4. Civil Engineering

A number of introductory OS&H topics are covered in two undergraduate courses; CE 4133 (Engineering Aspects of Environmental Health and CE 4143 (Man and His Environment). The combined OS&H content of these courses is roughly as follows:

Topic	Number of Lectures
Common Industrial Illnesses	1
Ergonomics & Human Factors	1
Heat Stress	1
Noise and Vibration	1
Nonionizing Radiation	4
Personal Protective Devices	½
Applied Industrial Toxicology	2
Sanitation	2
OS&H Program Structure andd Management	½
Legislative and Regulatory Requirements	1

Both courses are electives with CE 4143 attracting approximately 70 students per year and CE 4133 attracting approximately 45 students per year. CE 4143 is one of two so called "sociotechnology" courses, offered by schools in the Engineering College, which can be counted toward the social sciences requirement for the bachelors degree.

2.3.5 Electrical Engineering

With the exception of safety information associated with laboratory exercises, no OS&H information as such is provided. It does appear however that information is provided which would be useful to a practicing engineer for solving some OS&H problems, for example, EE 4026 "Audio Engineering" provides information useful for the design of sound level measuring equipment and EE 4041 "Illumination Engineering" for the design of industrial lighting systems.

2.3.6 Engineering Science and Mechanics

OS&H information is not currently included in course materials to any significant extent. The comments in 2.3.1. concerning the multiply listed accoustics courses apply here as well.

2.3.7 Health Systems

OS&H information is not currently included in course materials to any significant extent.

2.3.8 Industrial and Systems Engineering

The major contribution to OS&H training is in the area of human factors. Relevant material is presented in ISyE 3113, 6218, 6219, 6220, and 6221. Applied statistical techniques useful for many OS&H applictions are taught in ISyE 6739.

2.3.9 Mechanical Engineering

While it appears that a number of courses might contain OS&H related information the actual material presented tends to be more fundamental with little emphasis on such topics.

2.3.10 Nuclear Engineering

The undergraduate program does not contain any significant OS&H training. The graduate health physics program contains a required OS&H course (HP 6800, "Industrial Health Protection Survey") but undergraduates do not take it.

2.3.11 Textile Engineering

TEX 2180, "Textile Manufacturing Processes I," provides some OS&H training in the form of a 3 hour lecture which introduces the OS&H issues paramount in textile manufacturing and a requirement that each student view the American Textile Manufacturers Institute audiovisual safety program (a series of slides narrated on cassette tape). The school did at one time (has not been offered for the past few years) offer a special topic course devoted to OS&H in the textiles industry with emphasis on the regulatory structure.

2.4 Potential Curriculum Modification to Provide Increased OS&H COVERAGE

Each interviewee was asked if courses currently in the curriculum could be modified to include additional OS&H information. The following related issues were also discussed:

1. ways of facilitating such a change
2. probable faculty response
3. factors which would impeed such a change.

2.4.1 Aerospace Engineering

No specific courses were identified, but it was indicated that a number of topics were discused in the undergraduate curriculum which could be expanded to include related OS&H information (partial lectures, etc.). Bringing related OS&H information to the attention of the instructors would aid this process. Instructors would probably be cooperative, but their familiarity with the topics involved as well as their related personal experience would strongly impact on the extent of their participation.

2.4.2 Ceramic Engineering

No specific courses were identified. As indicated in 2.3.2 some OS&H infirmation, which is specifically related to major topics in the curriculum, is already included and this approach could be expanded. The availability of appropriate current OS&H information would facilitate this process. This information needs to stress well documented health or safety risks and suggestions or remedies which can be demonstrated to provide a real return (in terms of worker protection, reduced liability exposure, etc.) for the industry involved. Information of this sort would contribute to an "engineering education" i.e., provide understanding of real problems and suggest solutions which facilitate production. Faculty response would be generally positive.

2.4.3 Chemical Engineering

ChE 4414 and ChE 6613 could possibly be modified to include additional relevant OS&H information. Three additional options were suggested for adding OS&H information. These included:

1. The inclusion of 1 or 2 OS&H lectures (3 hrs each) per quarter in the four required laboratory coures (ChE 3302, ChE 3303, transport phenomena, and ChE 3309, ChE 3310, unit operations).

2. Integrate 3 to 6 lectures (1 hr) into ChE 4431 (Chemical Enginering Economics) and add a requirement for the inclusion of appropriate OS&H considerations in the design problem assigned in ChE 4434 (Plant Design).

3. The development of an equipment design course along the lines of ChE 4432 which emphasized OS&H related problems. This option would require the availability of a faculty member with a strong interest in the areas, a condition which does not exist at the moment.

It was indicated that the introduction of additional material could probably be achieved especially with the ready availability of relevant information, but that long term success hinged on the presence of a real academic interest on the part of the faculty. Without ongoing research the long term prospects for such an initiative are not bright.

2.4.4 Civil Engineering

OS&H related training, through elective courses in this department's undergraduate program, is the most comprehensive in the college. The student population in these courses is equivalent to approximatley 50% of the Senior CE class. Additional materials can be incorporated into these courses as relevant information becomes available to the instructor.

2.4.5 Electrical Engineering

The concensus here is that the courses in the required curriculum are already too crowded in terms of content. Senior Seminar was suggested as a possible home for one or two OS&H lectures.

2.4.6 Engineering Science and Mechanics

Relevant OS&H information could be built into existing courses. Information provided to instructors would assist this process.

2.4.7 Health Systems

HS 3118 (a facility design course) was suggested as a potential home for some relevant OS&H training. Assistance with identifying and obtaining information was cited as very important to the inclusion of OS&H materials in the HS curriculum.

2.4.8 Industrial & Systems Engineering

The content loading in most courses is high and the instructional staff has a heavy teaching load; factors which do not facilitate the restructuring of existing courses.

2.4.9 Mechanical Engineering

The situation is very similar to that in ISyE.

2.4.10 Nuclear Engineering

Three lectures (1hr) could perhaps be devoted to relevant OS&H topics in NE 3211 (Elements of Nuclear Engineering). NE 4230 (Nuclear Engineering Design) might incorporate more comprehensive OS&H considerations into the problems assigned. HP 4412 (Principles of Health Physics) might be expanded to include some important nonradiation OS&H information. The availability of materials is important to success.

2.4.11 Textile Engineering

Increasing the OS&H content of existing courses is difficult because of high current material loading.

2.5. Introduction of a New OS&H Course

The interviewees were asked to comment on the possibility for the development by their school of an OS&H course. The reaction to this suggestion was universally negative for one or both of two reasons; no one on the school's faculty has sufficient interest or background to develop the course or the faculty is already so leaded with courses that such an assignment is not possible.

A second scenerio was presented to the interviewees for comment. The scenario centers around a new OS&H course prepared on a college-wide basis as a technical elective. The course would be developed by a committee made up of Engineering College faculty and other appropriate individuals. The course would be a one quarter, three credit-hour multiply listed course, offered under a number assigned by any school choosing to offer it. The committee would develop a course content and choose instructors from the college to provide the lectures involved. These lectures and/or demonstrations would be video taped and the tapes would be used by the various schools when the course was offered. The video lectures would cover the OS&H topics deemed of general importance by the committee and a block of electures (approximatley 5) would be left open so that the course coordinator in the school could expand on material of particular importance in the school's discipline. Exams would be coordinated through the committee to facilitate student performance evaluation.

The response to this scenerio was generally positive with the faculty involved indicating a willingness to participate provided the associated demands on their time did not become excessive. The concensus was that advisors would probably encourage students to participate with the strength of this encouragement depending on the quality of the course and its success in transferring useful and valuable information. The course would, however, have to compete with electives related to other "burning" issues such as energy conservation in industry.

2.6 Other Suggestions for Integration of OS&H Training

It was suggested that guest lectures might be incorporated into some existing courses and that seminar speakers might be invited to discuss current issues in OS&H.

Appendix 1

COLLEGE OF ENGINEERING

Dean—William M. Sangster; *Associate Dean*—W. Denney Freeston; *Assistants to the Dean*—Carolyn C. Chesnutt, Madelyne Watson; *Director of Special Programs*—Carolyn C. Cannon.

General Information

The College of Engineering comprises eleven degree-granting schools of instruction and research. The ten schools of engineering offer programs of study and research leading to bachelor's, master's, and doctoral degrees, and the School of Health Systems offers programs leading to bachelor's and master's degrees. Certain of these schools also offer programs in one or more subdisciplines or subspecialties. These degree offerings are summarized in the following table.

The programs in engineering are designed to provide a fundamental understanding of the engineering sciences, which are based on mathematics and the natural sciences, and of the basic concepts of the humanities and social sciences; then to furnish an understanding of the manner in which these elements are interwoven in engineering practice. Each curriculum provides enough flexibility through elective course opportunities to permit a certain amount of program individualism, even as basic requirements are met.

Students who wish to study engineering but are undecided as to a specific engineering degree program may, for their freshman year, be classified as Undecided Engineering College (UEC) students. UEC students receive advisement from the Office of the Dean of Engineering. Course Work for Undecided Engineering students will focus in the areas of mathematics, chemistry, physics, humanities, and social science, as does the first year course work for all engineering degree programs.

College of Engineering Degree Programs

	B	M	PhD
Aerospace Engineering	X	X	X
Ceramic Engineering	X	X	X
Chemical Engineering	X	X	X
Metallurgy		X	X
Civil Engineering	X	X	X
Environmental Engineering		X	X
Electrical Engineering	X	X	X
Engineering Science and Mechanics	X	X	X
Health Systems	X	X	
Industrial and Systems Engineering	X	X	X
Operations Research		X	X
Mechanical Engineering	X	X	X
Nuclear Engineering	X	X	X
Health Physics	X	X	X
Textile Engineering	X	X	X
Textile Chemistry	X	X	
Textiles	X	X	

Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives in all curricula in engineering: EGR 1170, AE 1350, CERE 1010, CHE 1110,1750,CE 1503, EE 1010,1011, 1750, ESM 1101, 1750, HS 2011, ISYE 1010, ME 1110, 1750, NE 1100, TEX 1100.

Multidisciplinary Programs in Engineering

In addition to its degree programs, the College of Engineering provides unusual opportunities for specialized study in engineering through its multidisciplinary certificate program offerings. Any student in good standing who is pursuing a degree in one of the eleven schools of the Engineering College, or in one of the other colleges, may so select elective courses and the subjects of special problems or thesis research as to satisfy simultaneously both the requirements of his or her major degree program and the requirements of a specialized multidisciplinary program, provided that the school through which the standard degree is being sought is a participant in that program. Upon graduation, the successful student receives both the degree in the major field of study and a certificate attesting to successful completion of the particular related multidisciplinary program.

The table on page 80 shows both currently available multidisciplinary program offerings and those which are in the planning stage (identified by asterisks), as well as the degree levels of the programs.

General Requirements of Undergraduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating undergraduate student, while as individualized as possible, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) undergraduate multidisciplinary requirements are: (1) the program must relate the student's major area to the given multidisciplinary area; (2) courses must be taken under more than one academic unit; (3) at least four courses and twelve credit hours (not required by name and number in the student's major) must be taken in a coherent program; (4) at least three of those courses and nine credit hours must be at the 3000 level or higher; (5) at least two of those courses and six credit hours must be outside the major field (crosslisted courses may be counted outside the student's major); (6) a grade of C or better must be earned in each course counting toward a multidisciplinary certificate.

Multidisciplinary Programs

Multidisciplinary Program Area	Related Degree Levels		
Acoustical Engineering		M	PhD
Bioengineering	B	M	PhD
Computer Engineering		M	PhD
Energy Engineering	B	M	PhD
Engineering Design		M	PhD
Environmental Studies		M*	PhD*
Manufacturing Systems	B*		
Materials Engineering	B	M	PhD
Mineral Engineering	B	M	PhD
Plastics Engineering	B	M	PhD
Pulp and Paper Engineering	B		
Structures Engineering		M	PhD
Systems Engineering		M*	PhD*
Transportation Engineering		M*	PhD*
Urban Engineering	B		

* = Programs in Planning Stage

School of Aerospace Engineering

Daniel Guggenheim School of Aeronautics, Established in 1930

Director—Arnold L. Ducoffe; *Associate Director and Regents' Professor*—Robin B. Gray; *Regents' Professors*—Warren C. Strahle, Ben T. Zinn; *Professors*—Robert L. Carlson, James I. Craig, Howard D. Edwards, Don P. Giddens, Sathyanarayana V. Hanagud, John J. Harper, Wilfred H. Horton, James E. Hubbartt, Howard M, McMahon, G. Alvin Pierce, Edward W. Price, Lawrence W. Rehfield, James C. Wu; *Associate Professors*—Stanley C. Bailey, C. Virgil Smith, Jr.; *Assistant Professors*—Jechiel I. Jagoda, Spyridon G. Lekoudis.

General Information

The School of Aerospace Engineering prepares students at the bachelor's, master's, and doctoral levels for a career in vehicle engineering with primary emphasis on flight vehicles. The school is housed in three buildings having a floor space of 85,000 square feet with a majority of this space devoted to instructional and research laboratories.

Undergraduate Programs

The first two years focus on course work in the areas of chemistry, mathematics, physics, humanities, and social sciences. Aerospace disciplines and related engineering sciences are emphasized in the third and fourth years. The undergraduate curriculum is designed to provide each student with a general background for either industry or graduate school at the end of four years. The program stresses both the theoretical and experimental aspects of aerospace engineering.

A certain degree of specialization is available to undergraduate students through the proper choice of electives or certain substitutions for required courses or both, depending on the student's abilities and career objectives. These specialized disciplines are acoustics, aeroelasticity, aerospace vehicle design, bioengineering, experimentation and instrumentation, fluid dynamics of pollution, helicopters and V/STOL aircraft, propulsion, structural dynamics, structures and supersonic and hypersonic vehicles.

A pre-med track is available to undergraduate students. This requires an additional academic year of chemistry and one academic year of biology. Students may substitute these courses for the electives and for certain required courses in the present curriculum.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Elective EGR 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives[1]	X-X-3	X-X-3	....
CHEM 1101-2 Inorganic Chemistry	4-3-5	4-3-5	....
MATH 1307-8-9[2] Calculus, I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121[2] Physics	....	....	4-3-5
Electives[3] Humanities/Social Science/ Modern Language	3-0-3	3-0-3	6-0-6
Electives[4] Free	....	....	3-0-3
Electives[5] Physical Education	X-X-2	X-X-1	X-X-1
Totals	X-X-18	X-X-17	X-X-20

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
AE 2101 Introduction to Aircraft Structures	....	....	4-0-4
AE 2603[6] Digital Computers	....	....	1-6-3
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	3-0-3	....
MATH 2307[2] Calculus IV	5-0-5	....	....
MATH 2308[2] Calculus and Linear Algebra	....	5-0-5	....
MATH 2309[2] Ordinary Differential Equations	....	....	5-0-5
ME 3322 Thermodynamics	....	....	3-0-3
PHYS 2122-3[2] Physics	4-3-5	4-3-5	....

Course	1st Q.	2nd Q.	3rd Q.
Electives[3] Humanities/Social Science/ Modern Language	3-0-3	3-0-3	....
Electives[4]	....	....	3-0-3
Totals	15-3-16	15-3-16	16-6-18

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
AE 3000-1-2 Fluid Mechanics I, II, III	4-3-5	4-3-5	4-3-5
AE 3103 Fundamentals of Stress Analysis	3-0-3	....	....
AE 3104 Energy Methods and Stability of Structures	....	3-0-3	....
AE 3110 Structures Lab	1-3-2	....	....
EE 3700 Circuits and Instruments	3-0-3	....	....
EE 3710 Electronic Systems	....	3-0-3	....
ESM 4210 Mechanical Vibrations	....	....	3-0-3
ENGL 3023 Written Communication in Science, Business, and Industry	....	3-0-3	....
MATH 4582 Advanced Engineering Math	....	....	3-0-3
Electives[3] Humanities/Social Science/ Modern Language	3-0-3	6-0-6	6-0-6
Totals	14-6-16	19-3-20	16-3-17

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
AE 4000 Fluid Mechanics IV	4-3-5	....	....
AE 4101 Analysis of Thin-walled Structural Elements	3-0-3	....	....
AE 4102 Selected Topics in the Analysis of Aircraft Structures	....	....	3-0-3
AE 4110 Structures Lab	1-3-2	....	....
AE 4200 Vibration and Flutter	....	....	3-0-3
AE 4250 Jet Propulsion	....	5-0-5	....
AE 4350-1 Aerospace Engineering Design Project I, II	....	2-6-4	2-6-4
AE 4410 Vehicle Performance	3-0-3	....	....
AE 4500 Stability and Control	....	5-0-5	....
Electives[3] Humanities/Social Science/ Modern Language	....	....	3-0-3
Electives[7] Free	3-0-3	3-0-3	3-0-3
Totals	14-6-16	15-6-17	14-6-16

[1]See College of Engineering section in "Curricula and Courses of Instruction" for engineering electives. EE 1010 cannot be used.

[2]A "C" grade or better is required in each Math and Physics course.

[3]Eighteen credit hours in humanities and eighteen credit hours in social science are required for graduation. To satisfy these requirements, humanities and social science courses must be selected from the College of Engineering listings in "Information for Undergraduate Students." Courses taken in humanities and social sciences must be scheduled as letter grade courses. ENGL 1001, 1002 plus three credit hours of English literature are required.

[4]These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

[5]See "Curricula and Courses of Instruction." Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Ceramic Engineering

Established in 1924

Director—Joseph L. Pentecost; *Professors*, James F. Benzel, A. T. Chapman, Willis E. Moody; *Associate Professor*—Joe K. Cochran, Jr., *Research Engineer and Lecturer* --David N. Hill; *Special Lecturer*—R. A. Young.

General Information

The ceramic industry produces over $20 billion worth of products annually in the United States. These products range from brick, tile, glass, portland cement, and dinnerware to high-temperature refractories for furnace linings, abrasives, and sophisticated electronic components. These traditional products create a continuing demand for personnel trained in this field and new products which are continuously developing open new opportunities. Over the past twenty years these new products have included rocket nozzles and jet engine components, electronic circuitry for computers, and fiberglass products for nose cones and missiles. Current developments include automotive exhaust catalyst supports and other pollution control devices, new lighting techniques, and electrooptical materials.

The raw materials for ceramic products are the most plentiful minerals in the earth's crust. Consequently, many are relatively cheap and result in durable, economical, temperature-resistant materials that are in continuous demand for innovative design.

Ceramic engineering applies sound scientific and engineering principles to solve manufacturing problems in the industry. Frequently these problems are complex and challenging for chemical and physical reactions are occurring at high temperatures. Measurements are difficult and cost constraints for economical production are always present.

The School of Ceramic Engineering offers a four-year curriculum leading to the bachelor's degree and graduate work leading to Master of Science and Doctor of Philosophy degrees in ceramic engineering. The undergraduate curriculum is designed to prepare the degree candidate for a position in the ceramic industry or for graduate work. Courses are also offered to nonmajors to introduce them to ceramic materials and processes or to develop specific skills and knowledge in the application of ceramic materials.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1111-2 General Chemistry	4-3-5	4-3-5	....
CHEM 2113 Chemical Principles	....	....	3-3-4
ELECTIVE EGR 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives[1]	X-X-3	X-X-3	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives[3] Physical Education	0-4-1	0-4-1	2-2-2
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2] Free	....	....	3-0-3
Totals	14-10-17	14-10-17	16-5-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CERE 3101 Ceramic Data Handling	....	....	3-3-4
CERE 3002 Properties of Engineering Materials	....	....	2-3-3
ESM 2201 Statics	....	3-0-3	....
ESM 3301 Mechanics of Deformable Bodies	....	....	5-0-5
GEOS 2100 General Geology	3-0-3	....	....
GEOS 2102 General Geology Laboratory	0-3-1	....	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	....
Electives[2] Free	....	3-0-3	....
Totals	15-6-17	18-3-19	14-9-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
CERE 3003 Ceramic Processing I	3-3-4	....	....
CERE 3004 Ceramic Processing II	....	2-3-3	....
CERE 3105 Phase Equilibria for Ceramists	3-0-3	....	....
CERE 3006 Physical Ceramics I	3-0-3	....	....
CERE 3007 High Temperature Analysis	....	2-3-3	....
CERE 3008 Glass Technology I	....	2-3-3	....
CERE 4018 Drying and Psychrometry	....	....	2-0-2
CERE 4042 Seminar	....	1-0-1	....
CERE 4052 Inorganic Phase Analysis and Identification	....	....	3-3-4
CHEM 3412-3 Physical Chemistry	....	3-0-3	3-0-3
CHEM 3481 Physical Chemistry Laboratory	....	....	0-6-2
ME 3720 Thermodynamics	4-0-4	....	....
ME 3342 Transport Phenomena I or **ME 4714** Heat Transfer	....	....	3-0-3
ESM 3201 Dynamics I or **ESM 3302** Mechanics of Materials	3-0-3	....	....
Electives Humanities/Social Science/Modern Language	....	6-0-6	3-0-3
Totals	16-3-17	16-9-19	17-9-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
CERE 4102 Refractories	3-3-4	....	....
CERE 4003 Physical Ceramics II	....	2-3-3	....
CERE 4004 High Temperature Thermodynamics	....	....	2-0-2
CERE 4005 Glass Technology II	2-3-3	....	....
CERE 4110 Energy Conversion & Control	....	2-3-3	....
CERE 4115-6-7 Independent Research Project I, II, III	1-0-1	0-3-1	0-6-2
CERE 4043 Seminar	....	1-0-1	....
ISYE 4725 Engineering Economy	3-0-3	....	....
Elective Either EE 3700, Elements of Electrical Circuits and Instruments (3-0-3) or EE 3725, Electric Circuits and Fields (2-3-3)	X-X-3	....	....
Elective Metallurgy	....	3-0-3	....
Elective Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Elective Free	....	3-0-3	6-0-6
Totals	15-6-17	14-9-17	14-6-16

[1]See College of Engineering section "Curricula and Degrees" for engineering electives.
[2]These free elective courses may be taken at any time during a student's course of study.
[3]See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Chemical Engineering

Established in 1901
Director and Professor—Gary Poehlein; *Chemical Engineering Faculty—Professors*—Charles W. Gorton, Michael J. Matteson, John D. Muzzy, Robert J. Samuels, A. H. Peter Skelland, Jude T. Sommerfeld, Henderson C. Ward, Jack Winnick; *Associate Professors*—Larry J. Forney, William R. Ernst, Amyn Teja; *Assistant Professors*—Pradeep K. Agrawal, Allan S. Myerson, Ronnie S. Roberts, D. William Tedder, Mark G. White, Ajit P. Yoganathan, F. Joseph Schork; *Adjunct Professors*—George A. Fowles, Charles Aloisio, Jr.; *Metallurgy Faculty: Professors*—Robert F. Hochman; Helen Grenga, John Husted, Ervin E. Underwood; *Associate Professors*—Miroslav Marek, Pieter Muije. *Fracture & Fatique Research Laboratory—Professor and Director*—Edgar A. Starke, Jr.; *Research Scientists*—Fu-Shiong Lin, Koji Yamaguchi; *Post Doctorals*—Rong-Tsang Chen, Kumar Jatavallabula.

Chemical Engineering Program

General Information

Chemical engineers perform essential functions in industries that convert raw materials into useful finished products by means of chemical and physical processes. Almost every major manufacturing industry employs chemical engineers in research, development, design, production, sales, consulting, and management positions. Substantial numbers of chemical engineers are employed in petroleum, petrochemical, pulp and paper, plastics, metallurgical, fiber, fertilizer, nuclear energy, space, rubber, food, photographic, heavy and fine chemical, mineral, pharmaceutical, textile, and dye industries. Energy problems and environmental and pollution control activities require an increasing number of chemical engineers.

The School of Chemical Engineering offers programs leading to the degrees Bachelor of Chemical Engineering, Master of Science in Chemical Engineering, Master of Science in Metallurgy, and Doctor of Philosophy. The doctoral program may be in either chemical engineering or metallurgy. Interdisciplinary programs and undesignated degrees are also available.

The following curriculum leads to the degree of Bachelor of Chemical Engineering and is designed to train students both for positions immediately upon graduation or for additional study leading to the master's and doctoral degrees.

It is a requirement of the School of Chemical Engineering that every required chemical engineering course be passed with a grade of C or better.

A six-week summer study program in the Department of Chemical Engineering of the University College London in London, England was initiated in the summer quarter, 1975. Selected juniors who participated in this program are allowed twelve credit hours of free or technical electives, some of which may be substituted for selected chemical engineering laboratory courses.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHE 1101 Introduction to Chemical Engineering	1-0-1	....	....
CHEM[1] 1111-2 General Chemistry	4-3-5	4-3-5	....
CHEM 2113 Chemical Principles	....	....	3-3-4
ENGL[2] 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
MATH 1307-8-9 Calculus	5-0-5	5-0-5	5-0-5
Elective[3] Freshman Engineering Elective	....	X-X-3	....
Electives[4] Freshman Physical Education	X-X-2	X-X-1	X-X-1
Electives[5]	3-0-3	....	6-0-6
Totals	X-X-19	X-X-17	X-X-19

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHE 2207-8 Chemical Process Principles	3-0-3	3-0-3	....
CHE 2209 Computers in Chemical Engineering	....	....	2-3-3
CHE 3300 Transport Phenomena	....	....	3-0-3
MATH 2307-8 Calculus	5-0-5	5-0-5	....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381 Organic Chemistry Laboratory	....	0-6-2	....
Electives	....	....	3-0-3
Totals	15-3-16	15-9-18	15-6-17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHE 3301 Transport Phenomena	3-0-3	....	....
CHE 3302-3 Transport Phenomena Laboratory	0-3-1	0-3-1	....
CHE 3306-7 Unit Operations	....	3-0-3	3-0-3
CHEM 3411-2-3 Physical Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3481 Physical Chemistry Laboratory	....	....	0-6-2
ESM 2201 Statics	3-0-3	....	....
EE 3700 Electrical Circuits and Fields	....	....	3-0-3
EE 3740 Electrical Engineering Laboratory	....	....	0-3-1
MET 3301 Engineering Materials	....	4-3-5	....
Electives	6-0-6	6-0-6	6-0-6
Totals	15-3-16	16-6-18	15-9-18

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHE 4438 Chemical Engineering Thermodynamics	4-0-4	....	....
CHE 4415 Reactor Design	....	3-0-3	....
CHE 3308 Unit Operations	3-0-3	....	....
CHE 3309-10 Unit Operations Laboratory I, II	0-3-1	0-3-1	....
ICS 2250 Technical Information Resources	1-0-1	....	....
CHE 4431 Chemical Engineering Economics	3-0-3	....	....
CHE 4432 Process and Equipment Design	....	2-3-3	....
CHE 4434 Plant Design	....	....	1-6-3
CHE 4416 Process Control	....	3-3-4	....
Electives	6-0-6	6-0-6	12-0-12
Totals	17-3-18	14-9-17	13-6-15

Multidisciplinary Programs
See table on page 80.

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[1]CHEM 1111-2, advanced level chemistry, is required for all chemical engineering majors. Students transferring into chemical engineering from other curricula not requiring the advanced level chemistry will be allowed to substitute CHEM 1101-2 for CHEM 1111-2, respectively, if taken prior to transferring.
[2]ENGL 1001-2-3 is required for all chemical engineering majors and satisfies nine hours of the humanities requirement. Students transferring into chemical engineering from other curricula not requiring ENGL 1001-2-3 or students granted advanced placement will be allowed to substi-

School of Civil Engineering

Established in 1896

Director—J. Edmund Fitzgerald; *Assistant Director*—Paul H. Sanders; *Regents' Professors*—Satya N. Atluri, Paul G. Mayer, George F. Sowers; *Professors*—Richard D. Barksdale, Austin B. Caseman, Edward S. K. Chian, Donald O. Covault, Leroy Z. Emkin, Daniel W. Halpin, James S. Lai, Charles S. Martin, Frederick G. Pohland, Quentin L. Robnett, William M. Sangster, Thomas E. Stelson, Earl M. Wheby, Paul H. Wright; *Associate Professors*—Mustafa M. Aral, Larry J. Forney, Barry J. Goodno, Lawrence F. Kahn, Boris M. Khudenko, Billy B. Mazanti, Paily P. Paily, Peter S. Parsonson, F. Michael Saunders, Calvin W. Tooles, I. Edwin Wilks, Kenneth M. Will; *Assistant Professors*—Joseph P. Gould, Achintya Haldar, Edward R. Johnson, Byung R. Kim, Sai Hyun Lee, Srinivasa R. G. Rao, Philip J. W. Roberts, Terry W. Sturm; *Instructors*—Robert C. Bachus, Larry W. Hess, Hyman A. Todres; *Adjunct Professor*—Patrick M. Quinlan.

General Information

The School of Civil Engineering offers courses in civil engineering and engineering graphics and programs leading to the degrees Bachelor of Civil Engineering, Bachelor of Science (undesignated), Master of Science in Civil Engineering, Master of Science in Environmental Engineering, Master of Science (undesignated), and Doctor of Philosophy. Also offered is a joint two-year program leading to the awarding of the degrees Master of Science in Civil Engineering or Master of Science (undesignated, major in transportation engineering), and Master of City Planning.

Multidisciplinary Programs

See table on page 80.

Program in Engineering Graphics

The School of Civil Engineering offers EGR 1170, Introduction to Visual Communication and Engineering Design. This course is required in many engineering curricula and acceptable as an elective in the other engineering curricula and in many non-engineering curricula.

The objective of the course is to teach the student the principles of graphic expression. It is recommended that this course be scheduled during the freshman year, so that principles learned therein may be used in later engineering courses.

Bachelor of Civil Engineering

The four-year curriculum leading to the degree Bachelor of Civil Engineering is designed to enable the graduate to enter professional practice as an engineer or to continue his or her studies in programs leading to advanced degrees in the following broad fields of specialization: construction, environmental engineering, fluid mechanics, hydraulics, hydrology, materials, environmental engineering, soil mechanics, structures, surveying, transportation and water resources planning and management. The graduate of the B.C.E. curriculum may function in the areas of planning and design, construction, research and development, operations, and maintenance. The curriculum leading to the degree Bachelor of Civil Engineering has been continuously accredited by the Accreditation Board for Engineering and Technology since the inauguration of its accrediting program during the period 1936-38. Graduates of the B.C.E. curriculum are eligible to seek licensing as registered professional engineers.

The course requirements of the Bachelor of Civil Engineering degree are tabulated here. Many of the courses need not be taken during the quarter indicated, but prerequisites must be satisfied.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the following are also required for the B.C.E. degree.

(a) The scholastic average shall be a minimum of 2.0 for those quarters during which the last fifty-four hours toward the degree are taken.

(b) The number of quality points earned in civil engineering courses taken toward the degree must be at least twice the number of credit hours in those courses.

(c) No more than twelve hours of free electives may be taken on a pass/fail basis. No other courses may be taken on a pass/fail basis.

Students who complete both the bachelor's and master's degrees in the School of Civil Engineering may use up to nine credit hours of graduate level course work (as approved by the C.E. School) in the major discipline for both degrees. In order to qualify for this option the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the Master's degree within a two-year period from the award date of the bachelor's degree.

Freshman Year

Courses	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101 Inorganic Chemistry	4-3-5	....	....
BIOL 1720 Biological Principles	....	4-3-5	....
PHYS 2121 Physics	....	....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communications	2-3-3	....	....
CE 1503[1] Freshman Engineering Elective	....	2-3-3	....
ECON 2000 Economics	....	....	3-0-3
ENGL 1001-2 Introduction to Literature	3-0-3	3-0-3	....
Electives[6] Humanities/Social Science/Modern Language	....	....	3-0-3
Electives[2] Free	1-0-1	1-0-1	....
Electives[3] Physical Education	X-X-1	X-X-1	X-X-2
Totals	X-X-18	X-X-18	X-X-18

Sophomore Year

Courses	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 2122 Physics	4-3-5	....	....
Elective[7] Either PHYS 2123, Physics, or CHEM 1102, Inorganic Chemistry	....	4-3-5	....
CE 2264 Surveying	....	....	3-3-4
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
MATH 3709 Mathematics for Systems Engrg.	....	....	3-0-3
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics	....	3-0-3	....
ESM 3301 Mechanics of Deformable Bodies	....	....	5-0-5
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2] Free	1-0-1	1-0-1	1-0-1
Totals	16-3-17	16-3-17	15-3-16

Junior Year

Courses	*1st Q.*	*2nd Q.*	*3rd Q.*
CE 3513 Digital Computers	3-0-3	....	....
CE 3224 Structural Analysis	3-3-4	....	....
CE 3534 Stochastic Methods	3-3-4	....	....
GEOS 2100 Physical Geology	3-0-3	....	....
GEOS 2102 Physical Geology Laboratory	0-3-1	....	....
Elective[7] Either ME 3720, Thermodynamics or CHEM 2113, Chemical Principles	X-X-4	....	....
CE 4108-18 Environmental Engineering I, II	....	3-0-3	3-0-3
CE 3309 Materials of Construction	....	3-3-4	....
CE 3053-4 Fluid Mechanics I, II	....	3-0-3	3-3-4
ENGL 3023 Technical Writing	....	3-0-3	....
Elective[4] Free	....	3-0-3	....
CE 4204 Metal Structural Components	....	....	3-3-4
CE 4154 Behavior of Soil and Rock	....	....	3-3-4
EE 3700[8] Elements of Electrical Circuits and Instruments	....	....	3-0-3
EE 3740[8] Electrical Instrumentation Laboratory	....	....	0-3-1
Totals	X-X-19	15-3-16	15-12-19

Senior Year

Courses	*1st Q.*	*2nd Q.*	*3rd Q.*
CE 4214 Concrete Structural Components	3-3-4	....	....
CE 4163 Soil and Rock Engineering	2-3-3	....	....
CE 3061 Fluid Mechanics Laboratory	0-3-1	....	....
Electives[5] CE	3-0-3	3-0-3	3-0-3
CE 4353 Hydrology	3-0-3	....	....
Electives[6] Humanities/Social Science/Modern Language	3-0-3	6-0-6	6-0-6
CE 4304 Transportation Engineering I	....	3-3-4	....
ISYE 4725 Engineering Economy	....	3-0-3	....
CE 4003 Construction	....	....	2-3-3
Elective[4] Free	....	....	3-0-3
Totals	14-9-17	15-3-16	14-3-15

[1]See College of Engineering section "Curricula and Courses of Instruction" for engineering electives which can be substituted for CE 1503.

[2]These free elective courses may be taken at any time during a student's course at study. Physical education courses may not be used to satisfy this requirement.

[3]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for physical education requirements.

[4]Six hours of free electives at the 3000 level or higher, except Physical Education, must be taken if advanced ROTC is not taken.

[5]CE Electives. Nine hours chosen from 4000-level CE courses, not otherwise required in the BCE curriculum, or graduate level CE courses as approved by advisor and director (minimum of 2.7 average required for an undergraduate to take a graduate course).

[6]See "Information for Undergraduate Students" section of this catalog for humanities, social science, and modern language requirements.

[7]CHEM 1102 is prerequisite for CHEM 2113, recommended for specialization in Environmental Engineering. PHYS 2123 is corequisite for ME 3720.

[8]EE 3700 is corequisite for EE 3740, but the reverse is not true.

School of Electrical Engineering

Established in 1896

Director and Professor—Demetrius T. Paris; *Associate Director and Professor*—Roger P. Webb (Georgia Power Chair); *Assistant Director for Graduate Affairs and Professor*—Dale C. Ray; *Assistant Director for Undergraduate Affairs and Professor*—Thomas M. White, Jr.; *Regents' Professors*—John W. Hooper, George P. Rodrigue, Ronald W. Schafer (John O. McCarty/Audichron Chair), Kendall L. Su; *Professors*—Cecil O. Alford, Henry C. Bourne, Aubrey M. Bush, J. Alvin Connelly, Atif S. Debs, Robert K. Feeney, Daniel C. Fielder, Thomas K. Gaylord, Joseph L. Hammond, Jr., Edward B. Joy, Edward W. Kamen, John D. Norgard, John B. Peatman, Joseph M. Pettit, William T, Rhodes, Jay H. Schlag, Albert P. Sheppard, Jr., Charles R. Vail; *Associate Professors*—Thomas P. Barnwell III, William R. Callen, Jr., John C. Field (visiting), G. Keith Huddleston, W. Marshall Leach, Jr., Russell M. Mersereau, Mohamed F. Moad, Hans B. Puttgen, William E. Sayle II, Glenn S. Smith, John M. Wallace, Jr.; *Assistant Professors*—Chee-Yee Chong, Mark A. Clements, Kent R. Davey, John F. Dorsey, Monson H. Hayes, Donald J. Healy, David R. Hertling, Frank L. Lewis, Stephen R. McConnel (visiting), Athan P. Meliopoulos, Mohamed G. Moharam, John P. Uyemura, Erik I. Verriest; *Instructor*—Thomas E. Brewer; *Lecturers*—William T. Anderson, Allen H. Cherin, Clayton H. Griffin, Robert D. Hayes, Christopher J. M. Hodges, Terence E. Keene, Terrence A. Lenahan, Jay T. Loadholt III, M. David Prince.

General Information

Electrical engineers have pioneered the fields of electronics, computers, control, power, and communication. Their work is vital in almost every sector of society. The tremendous effect of electrical engineering on society can be explained by the fact that electrical energy is the only known form of energy which can be transmitted efficiently under controlled conditions, even through a vacuum, and by means of which intelligence can be processed and transferred effectively even over extremely long distances.

The School of Electrical Engineering seeks to attract students who possess a verbal and written command of the English language, who exhibit logical thinking, creativity, curiosity, imagination, persistence, patience, and who have proved their academic excellence in mathematics, chemistry, and physics.

At the undergraduate level, the basic required program of instruction in fundamental theory and laboratory practice is balanced by a broad range of electives. These electives are available in a wide variety of major areas such as audio engineering, communications, computer engineering, energy engineering, instrumentation, controls, and optical engineering. The student, with the counsel and guidance of faculty advisors, designs his or her electives program around his or her own special interests.

The graduate programs leading to the master's and doctoral degrees are designed to provide a broad education covering more than one specialty, followed by in-depth studies of major and minor interest areas. The doctoral program requires, in addition, concentration in a single specialty or in a group of closely related specialties.

Graduate programs include communications, computer systems, control systems, electric power, optical engineering, electromagnetics, instrumentation, network and system theory, physical electronics, and signal processing. Multidisciplinary programs in areas such as computer engineering and acoustic engineering are offered jointly with other engineering schools on campus. Full programs of courses are offered during the summer quarter, making it possible for part-time students to continue an uninterrupted program of study throughout the year.

Housed in one of the finest facilities in the world, the school maintains a vigorous program of student-centered research conducted in well-equipped laboratories.

Additional information about the programs may be obtained from the school's *Student Handbook*, available upon request, or by calling the school at (404)894-2900. This source of information must be consulted with respect to special rules and degree requirements by every student enrolled.

Certificate Program in Computer Engineering

Computers have become an integral part of today's society and are now used in all facets of society including scientific research, industry, business, commerce, and now even the home with calculators and computer controlled appliances. With this increasing use comes an increasing demand for people who understand the design, construction, operation, and application of computers. To satisfy this demand, new programs in computer engineering have been developed.

Computer engineering in the School of Electrical Engineering encompasses both traditional areas of computer engineering—the engineering *of* computers and engineering *with* computers. Engineering *of* computers emphasizes the design of computers and requires expertise in computational theory, digital design, and computer architecture. Engineering *with* computers emphasizes the use of computers in engineering systems and requires computer interfacing techniques, both low level and high level programming techniques, and a general knowledge of computer operating systems. Both areas require an in-depth understanding of computer software at the elementary and systems level. Hence, computer engineering encompasses all aspects of design, theory, and practice relating to: systems for digital and analog computation and information processing; components and circuits for computing systems; relevant portions of supporting disciplines; production, testing, operation, and reliability of computing systems; applications, use, and programming of computing devices and information processing systems; and the use of computers in electrical and electronic engineering.

Those undergraduate engineering students who specialize in the area of Computer Engineering will be awarded a Certificate in Computer Engineering. To qualify for this certificate, a student must complete all requirements for an ABET-accredited bachelor's degree in an engineering discipline and, in addition, must successfully complete, with a grade of C or better, the following nine elective courses, totaling thirty quarter hours: EE 1010, EE 3032, EE 3033, EE 3034, EE 4075, EE 4077, EE 4080, ICS 2100, and MATH 2020. None of these courses are to be required by title and number for the bachelor's degree in the student's major field. Non-electrical engineering students may substitute EE 3360 for one of the EE courses listed in the program.

Further details may be obtained by directly contacting the School of Electrical Engineering.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Electives[1]	....	3-0-3	3-0-3
Electives[2] Humanities/ Social Science/ Modern Language	....	....	3-0-3
ENGL 1001-2	3-0-3	3-0-3	....
Elective Any one of the freshman engineering electives[5]	X-X-3	....	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	....	....	4-3-5
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
Electives[3] Physical Education	X-X-2	X-X-1	X-X-1
Totals	X-X-18	X-X-17	X-X-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Electives[1]	3-0-3	....	....
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	....	3-0-3
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus V	....	5-0-5	....
MATH 3308 Differential Equations	....	....	5-0-5
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
EE[4] **3200-50** Elements of Electrical Engineering	....	3-0-3	3-0-3
EE 3400 Instrumentation Laboratory	....	....	1-3-2
Totals	18-3-19	15-3-16	15-3-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Electives[1]	1-0-1	4-0-4	4-0-4
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
EE 3300-10-20 Electromagnetics	3-0-3	3-0-3	3-0-3
EE 3210-20 Circuits and Systems	3-0-3	3-0-3	....
EE 3215 Signals and Systems	....	....	3-0-3
EE 3260 Engineering Electronics	3-0-3	....	....
EE 3270 Nonlinear Devices and Circuits	....	3-0-3	....
EE 3330 Electromechanical Systems and Energy Conversion	....	....	3-0-3
EE 3360 Digital Hardware	3-0-3	....	....
EE 3411-21-31 Junior EE Laboratory I, II, III	0-3-1	0-3-1	0-3-1
Totals	16-3-17	16-3-17	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Electives[1]	10-0-10	13-0-13	13-0-13
Electives[2] Humanities/ Social Science/Modern Language	3-0-3	3-0-3	3-0-3
EE 4350 Materials Science	3-0-3	....	....
EE 4411-21 Senior EE Laboratory I, II	0-3-1	0-3-1	....
EE 4430 Project Laboratory	....	....	0-3-1
Totals	16-3-17	16-3-17	16-3-17

[1]Electives: The electrical engineering curriculum contains fifty-seven hours of electives, in addition to four hours of specified physical education electives and thirty hours of specified humanities/social science/modern language electives. The fifty-seven hours of electives must include a minimum of:

Three hours of freshman engineering electives. See "Curricula and Courses of Instruction," College of Engineering.

Three hours of junior-level or senior-level course work in written or verbal communications of ideas which may be one of the following English courses: ENGL 3015, ENGL 3023, ENGL 3024.

Twelve hours of technical electives subject to school approval. Generally, the technical electives are junior or senior engineering (not EE), mathematics, or natural science courses. These electives must include one of the following five thermodynamics options: (1) ME 3720 (2) ME 3726 (3) ME 3322 and ME 3323 (4) PHYS 3141 or (5) a course or courses approved by the School of Electrical Engineering. In addition, one course in graphics is strongly recommended.

Eighteen hours of electrical engineering electives, subject to school approval.

Three hours (minimum) of applied probability selected from: (1) EE 3340 (2) PHYS 3145 (3) ISYE 3027 (4) BIOL 3333 (5) MATH 3710 (6) MATH 3215 or (7) MATH 4215. EE 3340 will apply toward satisfying the EE elective course requirements; all other courses will apply toward satisfying the technical breadth requirement for the bachelor's degree in electrical engineering.

Twenty-one hours of free electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit in the program.

[2]Three credit hours each of history and political science must be included. Additional humanities/social science/ modern language electives and their required distribution are given in "Information for Undergraduate Students," Academ-

School of Engineering Science and Mechanics

Established in 1959

Director and Professor—Milton E. Raville; *Associate Director and Professor*—Wilton W. King; *Regents' Professor*—Andrew W. Marris; *Professors*—William J. Lnenicka, David J. McGill, George M. Rentzepis, George J. Simitses, Charles E. S. Ueng, James T. S. Wang, Gerald A. Wempner; *Associate Professors*—Jerry M. Anderson, Donald G. Berghaus, Michael C. Bernard, Hyland Y. L. Chen, John C. Clark, Robert W. Shreeves, Raymond P. Vito, Wan-Lee Yin; *Assistant Professors*—William A. Johnston, Arthur J. Koblasz, Richard K. Kunz, John G. Papastavridis, Donald L. Vawter.

General Information

The School of Engineering Science and Mechanics administers the undergraduate curriculum leading to the degree of Bachelor of Engineering Science and Mechanics and graduate programs leading to the degrees of Master of Science, Master of Science in Engineering Science and Mechanics, and Doctor of Philosophy.

The primary objective of the undergraduate curriculum is to prepare students for careers in engineering and related fields emphasizing the fundamental principles and techniques of mathematics and the engineering sciences—solid mechanics, fluid mechanics, materials science, electrical sciences, heat transfer, and thermodynamics. The curriculum, totaling 206 credit hours, provides for 83 hours of electives, 30 hours of technical electives, 33 hours of humanities/social science/modern language electives, and 4 hours of physical education electives. The engineering science and mechanics curriculum is considered particularly well-suited for the above average student whose specific goals within the general framework of engineering and the physical sciences have not yet been formulated.

Elective options provide in-depth study in interdisciplinary, technically-related areas as well as preparation for professional schools of business, law, and medicine. Thus, the engineering science and mechanics graduate has a wide choice of specialized areas that can provide a foundation for starting his or her career or for further study.

The faculty members of the School of Engineering Science and Mechanics hold degrees in most of the recognized branches of engineering, as well as mathematics and physics. Housed in two buildings, ESM has excellent classroom, office and shop facilities, and modern, newly-equipped laboratories. Various grants, assistantships, and fellowships are available to students of outstanding merit.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Elective[1] Engineering	X-X-3	....	....
CHEM 1101-2 Inorganic Chemistry	4-3-5	4-3-5	....
EGR 1170 Visual Communication Engineering Design I	....	2-3-3	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Physics	....	....	4-3-5
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2] Free	....	....	3-0-3
Elective[5] Physical Education	X-X-2	X-X-1	X-X-1
Totals	X-X-18	X-X-17	X-X-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 2101-2 Engineering Design I, II	0-3-1	0-6-2	....
ESM 2201 Statics	3-0-3	....	....
ESM 3201-2 Dynamics I, II	....	3-0-3	3-0-3
EE 3200 Elements of Electrical Engineering	....	....	3-0-3
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 or 3308 Differential Equations	....	....	5-0-5

PHYS 2122-3 Physics	4-3-5	4-3-5	....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective[2] Free	....	....	3-0-3
Totals	15-6-17	15-9-18	17-0-17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 3111 Experimental Methods in Engr. Science	....	....	2-3-3
ESM 3301 Mechanics of Deformable Bodies	5-0-5	....	....
ESM 3302 Mechanics of Materials	....	3-0-3	....
ESM 3501 Fluids Mechanics	....	....	5-0-5
ESM 4210 Mechanical Vibrations	....	....	3-0-3
EE 3250 Elements of Electrical Engineering	3-0-3	....	....
EE 3400 Instrumentation Laboratory	....	1-3-2	....
ENGL 3023 Written Communication in Science, Business, and Industry	3-0-3	....	....
ME 3322 Thermodynamics	3-0-3	....	....
ME 3323 Thermodynamics	....	3-0-3	....
ME 3342 Transport Phenomena I	....	....	3-0-3
Elective[3] Mathematics	....	3-0-3	....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	....
Electives Free	....	3-0-3	3-0-3
Totals	17-0-17	16-3-17	16-3-17

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 3451 Computer Applications in Engineering Science& Mechanics	3-0-3	....	....
ESM 4122-3 Projects in Engineering Science	0-3-1	0-6-2	....
ECON 2000 Survey of Principles of Economics	3-0-3	....	....
MET 3301 Engineering Materials	4-3-5	....	....
Elective Either ISYE 4000, Introduction to Systems Theory, or ME 4445, Automatic Control	....	....	3-0-3
Elective[3] Mathematics	....	3-0-3	....
Elective[4] Physics	....	3-0-3	....
Electives Technical	3-0-3	6-0-6	6-0-6
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives* Free	....	....	4-0-4
Totals	16-6-18	15-6-17	16-0-16

*At east six hours of electives must be in the area of design, synthesis, or systems.

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[1]See College of Engineering section, "Curricula and Courses of Instruction" for engineering electives.
[2]These free elective hours may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then it should be scheduled beginning at the first quarter the student is enrolled. A maximum of nine hours of free electives in junior and senior years may be in advanced ROTC.
[3]To be selected from MATH 3110, 4215, 4320, 4581, 4582.
[4]To be selected from PHYS 3138, 3143, or 3751. If PHYS 3138 or 3143 is chosen, the extra two credits will be used as technical electives.
[5]At least six hours of electives must be in the area of design, synthesis, or systems.
[6]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Health Systems

Established in 1977, program in 1972, option in 1958

Director and Regents' Professor—Harold E. Smalley; *Professor*—James B. Mathews (adjunct); *Associate Professors*—Richard M. Bramblett (adjunct), Justin A. Myrick, Nathaniel Pugh, Jr.; *Assistant Professor*—Thomas H. Bowlin; *Lecturers*—Howard E. Fagin, Julian V. Pittman, Nelson F. Sayford, Milton E. F. Schoeman, Charles Y. Thomason, III; *Research Associate II*—Ann A. Bailey.

General Information

Health Systems is that field of study and practice aimed toward improving the delivery of health care services through the application of systems science and management engineering. Emphasis is upon systematic planning, engineering design, and scientific management in respect to health care facilities, manpower, and methods. Because of the complexity of health care management problems, the body of knowledge that has come to be known as health systems builds upon and draws from other branches of engineering, computer technology, management science, architecture, behavioral science, and the various health professions. Health systems is an allied health field grounded in the engineering profession.

A career in this field is challenging and rewarding in many ways. Health care is humanitarian and health services are important to society; the industry is large, expensive, and in need of improvement. A career in health systems is an opportunity to use modern scientific methods in the performance of a vital public service.

Health systems specialists are in short supply and there are many job openings with hospitals, nursing homes, doctors' offices, government agencies, universities, medical centers, research and planning organizations, manufacturers of hospital equipment, health insurance companies, management consultants, architectural firms, and construction contractors.

The School of Health Systems is an academic division of Georgia Tech's College of Engineering and it is affiliated with the Medical College of Georgia. The school has extensive programs of education, research and service, and through the Health Systems Research Center, it engages in interdisciplinary and interinstitutional research, continuing education, and community outreach activities.

Programs of the school are a direct outgrowth of faculty involvement in this field since 1952 and of a health-related academic program begun at Georgia Tech in 1958. The school has been admitted to institutional membership in the Georgia Hospital Association and the American Hospital Association, the American Society of Allied Health Professions, the American Health Planning Association, and the Association of University Programs in Health Administration. Close working relationships are also maintained with the Hospital Management Systems Society and with the Health Services Division of the American Institute of Industrial Engineers.

B.S.H.S. Curriculum

The undergraduate program was designed to prepare students for professional careers in the field of health systems, and it provides an academically sound base for lifelong learning. Even though it is technical and analytical, the program of study places some emphasis upon interpersonal, organizational, and societal relationships. Although it is directed toward the health field, the program provides students with valuable knowledge and marketable skills needed in many different fields.

The curriculum enables students to keep their options open for a variety of positions in the health field. It provides considerable flexibility so that students from various fields can transfer into it without losing credit already earned. It contains sufficient electives to accommodate several specialty interests, including health systems analysis, health systems planning, and premedical preparation. Modified versions of this curriculum are available under the dual degree (3—2) program.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2 General Chemistry	....	5	5
EGR 1170 Engineering Graphics	3	....	....
ENGL 1001-2[1] Analysis of Literature	3	3	....
HS 1000 Overview of Health Systems	1	....	....
MATH 1307-8-9 Calculus I, II, III	5	5	5
POL 1251[2] Government of the US[3]	....	3	....

Course	1st Q.	2nd Q.	3rd Q.
Elective English/Humanity[4]	....	....	3
Elective: HIST 1001 or 2[2] History of the U.S.[3]	3	....	....
Electives[5] Physical Education	2	1	1
Elective[2] Social Science	....	....	3
Totals	17	17	17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ECON 2000-1[2] Economic Principles	3	3	....
HS 2011 The Health Field	....	....	3
ICS 1700 Computer Programming	....	3	....
ISYE 3027 Applications of Probability	....	3	....
ISYE 3028 Engineering Statistice I	....	....	3
MGT 2000 Accounting I	....	....	3
MATH 2307 Calculus IV	5	....	....
PHYS 2121-2-3 Engineering Physics	5	5	5
Electives[4] Humanities	3	3	3
Elective[6] Free	3	....	....
Totals	19	17	17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ENGL 3023 Written Communications	....	3	....
HS 3011 Hospital Functions	3	....	....
HS 3021 Nonhospital Components	....	3	....
HS 3115-6 Management Engineering I, II	4	3	———
HS 3117-8 Management Engineering III, IV	....	3	3
HS 3211 Data Processing	....	....	3
HS 3351 Projects and Reports	....	....	3
ISYE 3025 Engineering Economy	....	....	3
ISYE 3029 Engineering Statistics II	3	....	....
ISYE 3131 Operations Research	....	....	3
MGT 2001 Accounting II	3	....	....
MGT 3060 Finance	....	3	....
Elective[6] Free	3	3	3
Totals	16	18	18

Senior Year

Course	*Credit Hours*
HS 4570 Field Training Proposal	1
HS 4571-2-3 Senior Externship	12
HS 4665 Case Studies	3
HS 4693 Seminar	1
ISYE 4101 Operations Planning	4
PSY 3303[2] General Psychology	3
Elective[8] Health Systems	3
Elective[9] Approved	15
Elective[6] Free	3
Senior-year Total	45
Total Degree Requirements	201

[1]These courses apply toward satisfaction of the eighteen-hour humanities requirement stated in "Information for Undergraduate Students."
[2]These courses apply toward satisfaction of the eighteen-hour social science requirement stated in "Information for Undergraduate Students."
[3]Either POL 1251 or 3200 gives exemption from the U.S. and Georgia constitution examination and any one of HIST 1001, 1002, 3010 or 3011 gives exemption from the U.S. and Georgia history examination. Students electing the examinations must substitute six hours of approved social science electives.
[4]Approved humanities courses are listed in "Information for Undergraduate Students." The eighteen hours of humanities must include ENGL 1001, 1002, and one other English course from the approved humanities list. The student should plan this and other electives with a view toward satisfying the rising junior English examination.
[5]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[6]A list of recommended electives is available upon request. Free elective hours may include credit for PE and/or ROTC courses up to the maximums stated in "Information for Undergraduate Students."
[7]Check the official school bulletin board for the quarters in which senior-year courses are expected to be offered.
[8]The student may choose any course with the HS prefix or a substitute course approved by the faculty.
[9]These courses must be selected from a faculty-approved list, and the set of selections must be approved by the student's advisor.

Health Planning Option

The health planning option is provided in order to broaden the preparation of the health systems specialist for professional practice in the subspecialty of health systems planning. Such a planning function covers manpower, facilities, logistics, organization, finances, and other system components. It includes consideration of medical, behavioral, socioeconomic, demographic, ethnic, political, legal, and other environmental factors. Some health systems planners serve in government agencies, consulting firms, or other organizations concerned with multi-institutional and community-wide systems of health care delivery. Others perform planning functions within management engineering departments of individual hospitals, clinics, or other health care institutions.

Health systems majors may emphasize health systems planning by utilizing their electives to include courses appropriate to the planning function. Such students should make their selections from the following categories:

Course	*Credit Hours*
Health Systems Elective:	
HS 3341	3
Social Science Elective:	
SOC 1376	3
Approved Electives:	
HS 3332	3
HS 3780	3
HS 4021	3
ISYE 4028, 4044, or ICS 4334	3
ISYE 4053, 4056, or 4157	3
Free Electives:	
CP 1100	3
ECON 3501, 4310, 4330, or 4331	3
MGT 4290 or POL 3250	3
POL 3217, 3220, 3221, or 4250	3
SOC 3310	3
Total	36

Premedical Option

The premedical option was designed to satisfy the normal course preparation required by most medical and dental schools while providing the systems orientation now being favored by leading medical educators.

Nationally, about two of every three medical school applicants are rejected and the proportion for professed premeds still in undergraduate school is even higher. A significant advantage of this premedical option is that if the student decides not to apply to medical or dental school or applies and is not admitted, he or she will be prepared to pursue an alternative health career.

Under this premedical option, health systems majors satisfy all required courses of the B.S.H.S. curriculum and utilize their electives to include the key premed courses.

Thus, the graduate is fully qualified as a health systems specialist and is prepared for medical or dental school.

This option concentrates the premed courses in the freshman and sophomore years so as to gain the advantage of submitting the medical or dental school application early in the junior year. Therefore, a decision to elect this option should be made prior to or early in the freshman year.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1111-21 General Chemistry	5	5	....
CHEM 2113 Chemical Principles	....	....	4
EGR 1170 Engineering Graphics	3	....	....
ENGL 1001-2-3[2] Analysis of Literature	3	3	3
HS 1000 Overview of Health Systems	1	....	....
HS 2011 The Health Field	....	....	3
ICS 1700 Computer Programming	....	3	....
Math 1307-8-9 Calculus I, II, III	5	5	5
Elective English Humanity[8]	....	....	3
Elective[3] Physical Education	1	1	2
Totals	18	17	17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
BIOL 2210-1-2 Principles of Biology	5	5	5
CHEM 3311-2-3 Organic Chemistry	3	3	3
CHEM 3381-2 Organic Chemistry Lab	....	2	2
ISYE 3027 Applications of Probability	....	3	....
ISYE 3028 Engineering Statistics I	....	....	3
MATH 2307 Calculus IV	5	....	....
PHYS 2121-2-3 Engineering Physics	5	5	5
Totals	18	18	18

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ECON 2000-1[4] Economic Principles	....	3	3
ENGL 3023 Written Communications	....	3	....
HS 3011 Hospital Functions	3	....	....
HS 3021 Nonhospital Components	....	3	....
HS 3115-6 Management Engineering I, II	4	3	....
HS 3117-8 Management Engineering III, IV	....	3	3
HS 3211 Data Processing	....	....	3
HS 3351 Projects and Reports	....	....	3
ISYE 3029 Engineering Statistics II	3	....	....
MGT 2000-1 Accounting I, II	3	3	....
MGT 3060 Finance	....	....	3
PSY 3303[4] General Psychology A	3	....	....
Elective[5] Free	....	....	1
Totals	16	18	16

Senior Year[6]

Course	Credit Hours
HS 4570 Field Training Proposal	1
HS 4571-2-3 Senior Externship	12
HS 4665 Case Studies	3
HS 4693 Seminar	1
ISYE 3025 Engineering Economy	3
ISYE 3131 Operations Research	3
ISYE 4101 Operations Planning	4
POL 3200[4] American Constitutional Problems[7]	3
PSY 3304[4] General Psychology B	3
Elective: HIST 3010 or 1[4] History of the U.S.[7]	3
Electives[2] Humanities	9
Senior-year Total	45
Total Degree Requirements	201

[1]The CHEM 1111-2, 2113 series is designed for students with good preparation in high school chemistry. It is recommended that students in doubt start with the CHEM 1101-2 series and switch to CHEM 1112 or to 2113 if good grades are made in CHEM 1101-2.
[2]These courses apply toward satisfaction of the eighteen-hour humanities requirement stated in "Information for Undergraduate Students."
[3]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[4]These courses apply toward satisfaction of the eighteen-hour social science requirement stated in "Information for Undergraduate Students."
[5]A list of recommended electives is available upon request. Free elective hours may include credit for PE and/or ROTC courses up to the maximums stated in "Information for Undergraduate Students."
[6]Check the official school bulletin board for the quarters in which senior-year courses are expected to be offered.
[7]Any one of HIST 1001, 1002, 3010, or 3011 gives exemption from the U.S. and Georgia history examination and either POL 1251 or 3200 gives exemption from the U.S. and Georgia constitution examination. Students electing the examinations must substitute six hours of approved social science electives.
[8]Approved humanities courses are listed in "Information for Undergraduate Students." The eighteen hours of humanities must include ENGL 1001, 1002, and one other English course from the approved humanities list. The student should plan this and other electives with a view toward satisfying the rising junior English examination.

School of Industrial and Systems Engineering

Director—Michael E. Thomas, Frank F. Groseclose (Emeritus); *Associate Director for Undergraduate Programs*—Nelson K. Rogers; *Associate Director for Graduate Programs*—William W. Hines; *Professors*—Mokhtar S. Bazaraa, Leslie G. Callahan, Stuart J. Deutsch, Paul T. Eaton (Emeritus), Augustine O. Esogbue, David E. Fyffe, John J. Jarvis, Robert G. Jeroslow (Adjunct), Cecil G. Johnson, Lynwood A. Johnson, Patrick D. Krolak, Robert N. Lehrer, Douglas C. Montgomery, H. Donald Ratliff, William B. Rouse, C. M. Shetty, Matthew J. Sobel (Adjunct), Rocker T. Staton (Emeritus), Gerald J. Thuesen, Harrison M. Wadsworth, Jr., John A. White, Jr; *Associate Professors*—Jerry Banks, Terence Connolly, Willard R. Fey, Russell G. Heikes, Leon F. McGinnis, Robert G. Parker, Alan B. Young; *Assistant Professors*—Faiz A. Al-Khayyal, John J. Bartholdi III, John S. Carson II, Yahya Fathi, John M. Hammer, Michael L. Pinedo, Loren K. Platzman, Craig A. Tovey; *Lecturers*—Edward H. Ely, Thomas L. Sadosky.

General Information

Industrial and systems engineering provides both a basic engineering foundation and a grounding in the interactions between technology and management. Students in the program are usually interested in obtaining a fundamental engineering background as the basis for professional specialization in activities associated with the field-operations research, management science, systems engineering, methods, organization, planning—or as preparation for other endeavors, such as management or as a foundation for law, medicine, or other pursuits. The study of industrial and systems engineering places emphasis upon developing the student's abilities to analyze and design systems that integrate technical, economic, and social behavioral factors in industrial, service, social, and government organizations. The degree program offered is the Bachelor of Industrial Engineering (B.I.E.)

B.I.E.

The principal strength of the program leading to the Bachelor of Industrial Engineering degree lies in a solid, well-coordinated core of courses in systems analysis and systems design, which relies heavily upon the engineering sciences, basic sciences, and social sciences. Elective hours make the program flexible as does the senior year design sequence, which permits a student to gain experience in design activities in manufacturing, service, or government industries. The broad spectrum of required course work associated with the design sequence qualifies the student to perform in operations and facilities, management information and controls, and systems engineering environments.

Options for Exceptional Students

An option program is available to encourage students with superior abilities to fully avail themselves of a range of unusual educational opportunities.

Participation in these programs requires demonstrated scholastic excellence, prior arrangements with the student's advisor and provides the following options, individually or in combination.

Graduate level courses in lieu of senior year electives

Students with a cumulative grade-point average of 3.3 or above may schedule up to nine credit hours of approved graduate level courses. These credits, when approved by the student's advisor, may be made available for subsequent credit toward a graduate degree.

Accelerated study

Students with a 3.3 or above average during the three preceding quarters (including at least forty-five credits), may complete course requirements for any nonproject industrial and systems engineering course at their own pace by self study with counseling and guidance by the course instructor. Students may register for any number of courses but must satisfy instructor and course examination requirements. Class attendance is not required. Arrangements must be made with course instructors prior to the start of the quarter.

Individual project and research work

Students with a 3.0 or above average during the preceding three quarters (including at least forty-five credits) may schedule up to twelve credits of project or research work or both, done in collaboration with the faculty or advanced graduate students, which may be substituted for senior-year electives. Students with less than a 3.0 average are limited to six credits of such project or research work.

Governor's Intern program
ISYE seniors enrolled in the governor's intern program may receive six hours of design credit (4104-5) and six hours of ISYE elective credit for participation in the program.

Visiting Scholar/Practitioner Offerings

Upon occasion, the school brings to campus selected individuals of unique accomplishment for course offerings built around their special areas of activity, thus making available a broader range of course materials than regularly provided. The typical schedule is Friday afternoon and evening instruction four times during the quarter.

Graduate Programs

The School of Industrial and Systems Engineering offers graduate programs leading to the degrees Master of Science in Industrial Engineering, Master of Science, Master of Science in Operations Research, and Doctor of Philosophy.

The M.S.I.E. program is available for students holding the B.I.E. degree and for other engineers who satisfy requisites covering the principal subject matter of the current B.I.E. curriculum. The M.S.O.R. program is available for students holding the B.S. in engineering, mathematics, or science. Requisites include work in probability, statistics, engineering economy, linear algebra, advanced calculus, and optimization. These requirements may be satisfied after enrollment; however, such course work may not be applied to satisfy degree requirements.

The undesignated M.S. is intended for those students who desire to follow programs in applied statistics, systems analysis, industrialization, or other special programs. Prerequisites are the same as for the M.S.O.R. program.

Except for the industrialization and systems analysis programs, a student has two options: either thirty-three quarter hours of course work and a thesis or fifty quarter hours of course work and a written comprehensive examination. The industrialization program requires forty-three quarter hours of course work and a thesis, and the systems analysis program requires thirty-three quarter hours of coursework and a thesis.

The doctoral program is intended for highly gifted individuals for whom past accomplishments and evaluation indicate a high potential for successful completion of the program requirements and a subsequent creative contribution to the field. Admission is, therefore, dependent upon student qualification rather than educational background in any specified discipline.

All degree curricula of the school are offered on a twelve-month basis. Graduate programs may be started in any quarter.

Financial aid is available in the form of traineeships, fellowships, and research assistantships.

The B.I.E. Curriculum

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ENGL 1001-2-3[6] Introduction to Literature	3-0-3	3-0-3	3-0-3
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design I	2-3-3	....	....
Elective[4] Engineering	....	X-X-3	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
Electives[1] Physical Education	X-X-2	X-X-1	X-X-1
Electives[2] Social Science	....	....	3-0-3
Totals	X-X-18	X-X-17	X-X-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
ESM 2201 Statics	....	....	3-0-3
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
Electives[3] Humanities	3-0-3	3-0-3	3-0-3
ECON 2000-1 Principles of Economics	3-0-3	3-0-3	....
MGT 3700[5] Analysis of Financial Data	....	....	4-0-4
ICS 1700 Digital Computer Organization and Programming	....	3-0-3	....
ISYE 3027 Applications of Probability	....	....	3-0-3
MATH 3709 Math for Systems Engineering	....	....	3-0-3
Elective[2] Social Science	3-0-3	....	....
Totals	18-3-19	18-3-19	16-0-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 3201 Dynamics I	3-0-3	....	....
ESM 3301 Mechanics of Deformable Bodies	....	5-0-5	....
ME 3720 Thermodynamics	....	....	4-0-4
ISYE 3028-9 Engineering Statistics I, II	3-0-3	3-0-3	....
ISYE 3105 Organizational Structures	3-0-3	....	....
ISYE 3025 Engineering Economy	3-0-3	....	....
ISYE 3010 Man-Machine Systems	....	3-0-3	....
ISYE 3115 Industrial and Systems Engineering Measurements	....	....	3-0-3
ISYE 3260 Introduction to Systems Engineering	3-0-3	....	....
ISYE 3131-2 Operations Research I, II	....	3-0-3	3-0-3
ISYE 4044 Simulation	....	....	2-3-3
ISYE 3100 The Professional Practice of Industrial and Systems Engineering	....	....	0-3-1
ENGL 3015 Public Speaking	3-0-3	....	....
ENGL 3023 Written Communication in Science, Business and Industry	....	3-0-3	....
Elective Free	....	....	3-0-3
Totals	18-0-18	17-0-17	15-6-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
EE 3700 Elements of Electric Circuits and Instruments	3-0-3	....	....
ISYE 4101 Operational Planning and Scheduling	3-3-4	....	....
ISYE 4102 Operations and Facilities Design	3-3-4	....	....
ISYE 4103 Management Information and Control Systems	....	3-0-3	....
ISYE 4104-5 ISYE Design I, II	....	0-9-3	0-9-3

ISYE 4039 Quality Control	3-0-3	....	....
Electives ISYE	....	6-0-6	6-0-6
Electives[2] Social Science	....	3-0-3	3-0-3
Electives Free	3-0-3	....	3-0-3
Totals	15-6-17	12-9-15	12-9-15

[1]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

[2]Social Science electives must include three hours of U.S. History, three hours of U.S. Government, and six credit hours of Social Science.

[3]See "Information for Undergraduate Students" for humanities electives to satisfy the College of Engineering requirements.

[4]See College of Engineering section "Curricula and Courses of Instruction" for freshman engineering electives.

[5]MGT 2000 and MGT 2001 may be substituted for MGT 3700 plus two hours of free electives.

[6]Freshmen who waive English 1001, 1002, or 1003 as a result of English Department Placement Tests may substitute 2000-level or higher English courses which qualify as Humanities.

School of Mechanical Engineering

Established in 1888

Acting Director and Professor—Walter O. Carlson; *Regents' Professors*—Peter Kezios, Allan D. Pierce; *Professors*—John T. Berry, William Z. Black, Gene T. Colwell, Steven L. Dickerson, Pandeli Durbetaki, Jerry H. Ginsberg, Alan V. Larson (Associate Director), Subbiah Ramalingam, Ward O. Winer; *Associate Professors*—Wayne J. Book, Prateen V. Desai, Thomas L. Eddy, Harold L. Johnson, Prasanna V. Kadaba, Samuel V. Shelton; *Assistant Professors*—Joseph A. M. Boulet, Robert B. Evans, Ronald T. Gibbs, James G. Hartley, Sheldon M. Jeter, Larry D. Koffman, William J. Wepfer, Wendell M. Williams, Paul J. Yoder; *Instructor*—Carolyn W. Meyers; *Lecturers*—James W. Brazell, Craig A. Depken, Guy W. Gupton, Kenneth W. Jackson, Harry I. Leon, Robert W. Newman; *Research Engineer*—Scott S. Bair.

General Information

Mechanical engineering traditionally deals with the largest diversity of engineering problems. Because of this general nature, mechanical engineering allows a number of multidisciplinary activities to be conveniently organized within it.

Mechanical engineering embraces the generation, conversion, transmission, and utilization of thermal and mechanical energy, the design and production of tools and machines and their products, the consideration of fundamental characteristics of materials as applied to design, and the synthesis and analysis of mechanical, thermal, and fluid systems, including feedback and control. Design, production, operation, administration, economics, and research are functional aspects of mechanical engineering.

The undergraduate curriculum covers the fundamental aspects of the field, emphasizes basic principles, and educates the student in the use of these principles to reach optimal design solutions for engineering problems. Specific design subject matter and materials are also drawn from such engineering activities as solar energy and biomechanical systems, as well as from the more traditional areas.

Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics. The junior and senior years are devoted to the strength of materials and metallurgy, applied mechanics, heat transfer, fluid mechanics, systems and controls, design, and the application of fundamentals to the diverse problems of mechanical engineering. Laboratory work and design projects are stressed.

Satisfactory completion of the curriculum leads to the degree Bachelor of Mechanical Engineering. All required mathematics courses must be passed with a grade of "C" or better.

Optional Programs

While the curriculum is structured to meet the general educational goals of the majority of mechanical engineering students, the school regularly considers and approves modifications of the basic program to allow a student with certain well-conceived educational objectives to pursue minor fields within the school or within Georgia Tech while earning a degree in mechanical engineering. In this way a student may achieve his or her basic degree in mechanical engineering while specializing in any one of a large number of other fields. The student who follows the regular ME curriculum takes a number of electives as well as special problems and projects, all of which allow latitude in pursuing his or her educational goals and special interests.

School Facilities

The School of Mechanical Engineering has many types of specialized instruments and equipment associated with laboratories for the study of two-phase flow, lubrication and rheology, material processing, fire hazard and combustion, magnetogasdynamics, energetics, fluidics and fluid power control, heat transfer, vibration and thermal stress, computer-aided design, automatic and digital control, machinery noise, plasmas, robotics, and other areas. The school is housed in a four-building classroom-research complex. Part of this complex is a modern classroom-seminar conference building which serves the Institute.

The main research building of the school houses several remote terminals linked to the main campus research and teaching computer. It also has analog and microcomputer facilities. The school research activity is served by its own machine and instrumentation shops with a full-time supporting staff of technicians.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication	2-3-3	....	....
Elective Freshman Engineering Elective[1]	....	X-X-3	....
ME 1001 Introduction to M.E	....	....	1-0-1
Electives[4] Humanities Social Science Modern Language	3-0-3	3-0-3	3-0-3
Electives[5] Physical Education			
Aquatics	X-X-1	....	....
Fitness	....	....	X-X-2
Elective	....	X-X-1	....
Electives[2] Free	2-0-2	2-0-2	2-0-2
Totals	X-X-19	X-X-19	X-X-18

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 Differential Equations	....	....	5-0-5
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	....	3-0-3
ESM 3301 Mechanics of Deformable Bodies	....	5-0-5	....
ME 2212 Materials Science	....	....	3-0-3
Electives[4] Humanities Social Science Modern Language	3-0-3	3-0-3	6-0-6
Totals	15-3-16	17-3-18	17-0-17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ME 3322-3-4 Thermodynamics	3-0-3	3-0-3	3-0-3
ME 3342-3-4 Transport Phenomena I, II, III	3-0-3	3-0-3	3-3-4
EE 3725 Electric Circuits and Fields	2-3-3	....	....
EE 3726 Elementary Electronics	....	2-3-3	....
EE 3727 Electric Power Conversion	....	....	2-3-3
ME 3212 Materials Technology	3-3-4	....	....
ME 3016 ME Computer Applications	....	2-3-3	....
ME 3055 Experimental Methodology	....	....	1-3-2
ME 3113 Kinematics and Dynamics of Linkages	3-0-3	....	....
ME 3114 Dynamics of Machinery	....	....	3-0-3
ME 3181 Machine Elements	....	3-0-3	....
Electives[4] Humanities Social Science Modern Language	....	3-0-3	3-0-3
Totals	14-6-16	16-6-18	15-9-18

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ME 4183 Design Theory	3-0-3	....	....
ME 4184 Design Engineering	....	....	0-6-2
ME 4318 Thermal Systems Analysis and Design	....	4-0-4	....
ME 4055 Experimental Engineering	....	....	1-3-2
ME 4344 Transport Phenomena IV	3-0-3	....	....
ME 4212 Material Processes	....	3-3-4	....
ME 4445 Automatic Control	3-0-3	....	....

ISYE 4725 Engineering Economy	3-0-3	....	....
Electives[3] Technical	....	3-0-3	6-0-6
Electives[4] Humanities Social Science Modern Language	3-0-3	3-0-3	3-0-3
Electives[6] ME Design	....	3-0-3	....
Totals	15-0-15	16-3-17	10-9-13

[1]See College of Engineering section "Curricula and Courses of Instruction" for engineering electives.

[2]These free elective courses may be taken at any time during the course of study. If ROTC is elected by the student these six credit hours may be applied for basic ROTC, which should be scheduled beginning the first quarter the student is enrolled.

[3]Nine hours of technical electives chosen from ME 3000, 4000, and 6000 level courses. Graduate courses (6000 level) must have consent of advisor. Courses other than these may be selected from mathematics, physics, chemistry, biology, another field of engineering, or graduate courses.

A student who wishes to take courses not in ME must so notify the director concerning his or her choice and obtain approval at advance registration for the first quarter of his or her senior year. A lab course (2-3-3) may be scheduled in place of a (3-0-3) course. A student completing his or her junior year with a grade average of 2.5 or higher may elect one technical elective from the special problem courses ME 4901 through 4912. (The particular course selected depends on the number of hours of credit needed.) This student will follow a course of individual study under the guidance of a faculty member with the approval of the school director. Nine hours of electives may be replaced by advanced ROTC.

[4]For selection of acceptable courses see list of electives allowed by the College of Engineering in "Information for Undergraduate Students."

[5]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

[6]Approved design electives are marked with an asterisk in the list of ME courses.

School of Nuclear Engineering and Health Physics

Established in 1962

Director—L. E. Weaver; *Callaway Professor*—W. M. Stacey, Jr.; *Neely Professor*—M. W. Carter; *Regents' Professor*—G. G. Eichholz, R. W. Carlson (Georgia Power Professor); *Professors*—J. D. Clement, M. V. Davis, D. S. Harmer, B. Kahn, J. M. Kallfelz, R. A. Karam, J. L. Russell, Jr., A. Schneider; *Associate Professors*—R. G. Bateman, Jr., J. L. Carden, Jr. (visiting), J. N. Davidson, J. W. Poston; *Adjunct Associate Professor*—P. H. McGinley.

General Information

Nuclear engineering is the branch of engineering directly concerned with the release, control, and utilization of all types of energy from nuclear sources and its environmental impact. Today nuclear energy is being used in a wide variety of applications from the exploration of outer space and the powering of human heart pacemakers to the generation of electricity. With the limited supply of fossil fuels and the growing concern about their environmental effect, the need for nuclear power to produce the large amounts of energy demanded by our society becomes more and more pressing. The School of Nuclear Engineering and Health Physics is playing a vital role in educating the technical manpower required to meet this need.

In addition to the Bachelor of Nuclear Engineering degree, the school administers the program leading to the Bachelor of Science degree in Health Physics. Health physics is an applied science concerned with the protection of man and the environment from the hazards of radiation and chemical pollutants. Typical activities of health physicists today are: development of sound philosophy and principles of radiation protection; practical application of these principles on the job in an industrial or medical setting or with a regulatory agency; and devising new methods and instrumentation for the protection of individual workers and the general public.

Undergraduate Programs

The curriculum leading to the degree Bachelor of Nuclear Engineering is structured to meet the needs of both the student who contemplates employment immediately after graduation and the student planning to pursue graduate study. It has been tailored to provide maximum flexibility in the form of options for each student to develop his or her unique interests or capabilities. These options are built upon the core curriculum covering the basic principles of nuclear engineering: nuclear reactor core design, nuclear fuel design, reactor controls engineering, nuclear fuel process engineering, nuclear power economics, and reactor operations.

Studies for the Bachelor's Degree in Health Physics may lead to careers in radiation protection or environmental surveillance, or may be preparatory to further study at the graduate level for a professional career as a health physicist. The program also provides an excellent premedical education. In addition to the Institute's academic requirements for graduation with a bachelor's degree, the number of quality points earned in nuclear engineering courses taken toward the B.N.E degree or B.S.H.P degree must be at least twice the number of credit hours in those courses. Further, students in the B.N.E degree program must obtain twice the number of quality points as credit hours for courses taken in thermodynamics and transport phenomena.

Program for the Bachelor of Nuclear Engineering

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design	....	2-3-3	....
EE 1010[3] Computer Programming and Graphics	....	....	2-3-3
Elective[1] Engineering	2-3-3	....	....
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[5] Physical Education	0-4-1	2-2-2	0-4-1
Totals	14-10-17	16-8-18	14-10-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 Ordinary Differential Equations	....	....	5-0-5
ESM 2201 Statics	....	3-0-3	....
ESM 3201 Dynamics	....	....	3-0-3
ISYE 4725[3] Engineering Economy	....	....	3-0-3
Electives[2] Free	3-0-3	2-0-2	3-0-3
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	15-3-16	17-3-18	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 3001 Modern and Nuclear Physics	5-0-5	....	....
NE 3211 Elements of Nuclear Engineering	3-0-3	....	....
NE 4201-2 Nuclear Reactor Physics I and II	....	3-0-3	3-0-3
HP 4412 Principles of Health Physics	....	3-0-3	....
NE 3110 Radiation Detection	....	....	2-6-4
ESM 3301 Mechanics of Deformable Bodies	....	....	5-0-5

Course	1st Q.	2nd Q.	3rd Q.
ME 3322-3 Thermodynamics	3-0-3	3-0-3	....
CHE 3300-1[3] Transport Phenomena	....	3-0-3	3-0-3
CHE 3302[3] Transport Phenomena Laboratory	....	....	0-3-1
MATH 4582 Advanced Engineering Mathematics	3-0-3	....	....
MATH 4581[3] Advanced Engineering Mathematics	....	3-0-3	....
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	17-0-17	18-0-18	16-9-19

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
NE 4211-2 Reactor Engineering I and II	3-0-3	3-0-3	....
NE 4230 Nuclear Engineering Design	....	....	2-6-4
NE 4205 Reactor Laboratory	1-6-3	....	....
NE 4001-2-3 Nuclear Engineering Seminar	1-0-1	1-0-1	1-0-1
NE 4260 Radiation Transport and Shielding	....	3-0-3	....
MET 4403[3] Introductory Nuclear Metallurgy	....	3-3-4	....
CHE 3303[3] Transport Phenomena Laboratory	0-3-1	....	....
EE 3725 Electric Circuits and Fields	....	....	2-3-3
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[4] Technical	6-0-6	3-0-3	3-0-3
Electives[2] Free	....	....	3-0-3
Totals	14-9-17	16-3-17	14-9-17

[1]For selection of College of Engineering approved elective courses and requirements see "Curricula and Courses of Instruction." EE 1010 cannot be used as a substitution.
[2]Free elective courses may be taken at any time during the course of study. If ROTC is elected by the student, six credit hours may be applied for basic ROTC and a maximum of five credit hours for advanced ROTC. (A maximum of nine credit hours of electives may be used for advanced ROTC-five hours free electives and four hours technical electives).
[3]Other courses may be substituted for these required courses. Substitutions are available from the general office of the School of Nuclear Engineering and Health Physics.
[4]The electives will be selected by the student after consultation with his or her advisor. At least ten credit hours must be in the areas of design, synthessm, and systems. A maximum of four credit hours of technical electives may be used for advanced ROTC.
[5]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[6]See Humanities and Social Sciences Requirements in "Information for Undergraduate Students."

Program for Bachelor of Science in Health Physics

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
MATH 1307-8-9 Calculus, I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design	....	2-3-3	....
Elective[1] Technical	2-3-3	....	....

Course	1st Q.	2nd Q.	3rd Q.
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective[3] Physical Education	0-4-1	2-2-2	0-4-1
Elective[4] Free	....	....	3-0-3
Totals	14-10-17	16-8-18	15-7-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 Ordinary Differential Equations	....	....	5-0-5
BIOL 2210-1 Principles of Biology	4-3-5	4-3-5	....
EE 1010 Computer Programming and Graphics	....	....	2-3-3
HP 2401-2-3 Introduction to Health Physics	1-0-1	1-0-1	1-0-1
Electives[4] Free	....	....	6-0-6
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	17-6-19	17-6-19	17-3-18

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 3001 Introduction to Modern Physics	5-0-5	....	....
PHYS 3211 Electronics	3-0-3	....	....
NE 3110 Nuclear Radiation Detection	....	....	2-6-4
HP 4411-2-3 Radiation and Health Physics	3-3-4	3-0-3	3-3-4
MATH 4582 Advanced Engineering Mathematics	3-0-3	....	....
BIOL 3335 General Ecology	3-0-3	....	....
BIOL 4915/6730 Introduction to Radiation Biology	....	....	3-3-4
BIOL 3333[5] Biostatistics	....	3-3-4	....
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[6] Technical	....	....	3-0-3
Totals	17-3-18	14-9-17	14-12-18

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
NE 4001-2-3 Nuclear Engineering Seminar	1-0-1	1-0-1	1-0-1
CHEM 4701 Chemistry of Nuclear Technology	....	3-3-4	....
PHYS 4211 Electronic Instruments	....	2-3-3	....
NE 4260 Radiation Shielding	....	3-0-3	....
HP 4401-2-3 Health Physics Seminar	1-0-1	1-0-1	1-0-1
HP 4440 Non-ionizing Radiation	3-0-3	....	....

NE 4701-2-3 Nuclear Reactor Engineering	3-0-3	3-0-3	3-0-3
NE 4903 Special Problem in Health Physics	....	....	0-9-3
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[4] Free	6-0-6	....	3-0-3
Elective[6] Technical	....	....	3-0-3
Totals	17-0-17	16-6-18	14-9-17

[1]For selection of approved elective courses, see Freshman Engineering Electives in "Curricula and Courses of Instruction," College of Engineering. EE 1010 cannot be used as a substitution.
[2]See Humanities and Social Sciences Requirements in "Information for Undergraduate Students."
[3]See Department of Physical Education and Recreation in "Curricula and Courses of Instruction."
[4]If ROTC is elected by the student, a maximum of six credit hours of basic ROTC and nine credit hours of advanced ROTC may be counted as free elective hours
[5]Other courses in statistics or data analysis may be substituted. A list of these courses is available in the general office of the School of Nuclear Engineering.
[6]Technical electives will be selected by the student after consultation with his or her advisor.

Facilities

The facilities available on the Georgia Tech campus for instruction and research in nuclear engineering include the following: a 5-megawatt research reactor, a lowpower training reactor, a sub-critical assembly, a 100,000 curie cobalt-60 source, several small digital computers, a CDC CYBER 170/130 and 170/760 computer, hot cells for handling radioactive materials, a complete nuclear instrumentation laboratory, and facilities for analyzing environmental samples by nuclear techniques.

School of Textile Engineering

Established in 1899

Director—Albin F. Turbak; *Callaway Professor*—John L. Lundberg; *Professors*—Winston C. Boteler, Walter C. Carter, W. Denney Freeston, Wayne C. Tincher; *Associate Professors*—Wallace W. Carr, Fred L. Cook, L. Howard Olson, Agaram S. Abhiraman; *Instructors*—Paul E. Hilley, McCamie F. Davis.

General Information

Textiles, one of man's oldest commercial ventures, continues to find new applications in the modern world. Fiber assemblies have many varied uses in our everyday life and are playing critical roles in new complex systems in space, medicine, safety, environmental control, transportation, and construction.

Textile engineering encompasses the synthesis of polymers by nature and man, fiber fabrication processes, assembling of fibers into one-, two- and three-dimensional structures, modification of structural properties through dyeing, finishing, and coating, and measurement of complex aesthetic and mechanical properties of fiberbased systems. New polymers and fibers, new methods of assembling fibers into useful products, and new applications of fibers are being developed continually.

The School of Textile Engineering prepares students for rewarding careers in the polymer-fiber-textile industry. Graduates have positions in manufacturing supervision, technical service, sales, product and process development, research, quality control, and corporate management. They participate in the design, development, manufacturing, and marketing of a broad range of fiber-based and associated products. Many hold key management decision-making positions at a young age.

The textile industry is by far the largest manufacturing industry and employer in the Southeast. If apparel and other associated segments of the industry are included, the textile-based industry is the largest in the United States, representing one out of every eight manufacturing jobs. This is more than five times the number employed in the automobile industry. The textile industry's needs for textile graduates each year far exceed the number of graduates.

Curricula

Three study programs are available leading to the degrees Bachelor of Textile Engineering, Bachelor of Science in Textile Chemistry, and Bachelor of Science in Textiles. Each degree may be pursued in a regular four-year program or the five-year cooperative plan.

A broad background is stressed because of the multidisciplinary nature of textiles. Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics, and in the junior and senior years on materials science, polymer and textile chemistry, applied mechanics, business administration, and application of each field to the broad range of problems encountered in textiles. All three programs provide for student selection of a number of courses from a wide range of general and technical electives.

In place of the many conventional laboratory sessions, textile students participate in a student operated and managed business venture. Students design, develop, produce, and market novelty textile products. Every participant is exposed to all facets of the business environment.

Since most of the textile course work is concentrated in the last two years of the programs, students from junior colleges and community colleges can readily transfer into selected programs of the School of Textile Engineering.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the number of quality points earned in textile courses taken toward the degree must be at least twice the number of credit hours in those courses.

The School of Textile Engineering is housed in the Hightower Building, a four-story classroom and laboratory facility. The building contains equipment illustrating most major types of textile processing. Well equipped laboratories are also available for the chemical and physical characterization of polymers, fibers, and fiber assemblies. Specialized equipment is available for fabric flammability studies, polymer environmental stability experiments, fiber-reinforced composite testing, and energy conservation and water pollution studies. Machine shop and instrumentation facilities with full-time supporting technicians are housed within the building.

Textiles For Other Majors

Students with other majors often enter the textile industry. To further their careers, the School of Textile Engineering has developed coordinated course offerings that will be helpful to students with this goal. Listings of recommended course sequences in textiles are available in the School of Textile Engineering office.

Program for Bachelor of Textile Engineering Degree

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
EGR 1170 Visual Communication and Engineering Design I	2-3-3	....	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	....	....	4-3-5
Electives[1] Physical Education	X-X-2	X-X-1	X-X-1
TEX 1100 Introduction to Textile Engineering	....	3-0-3	....
Elective Humanities/Social Science/Modern Language	....	....	3-0-3
ICS 2250 Technical Information Resources	....	....	1-0-1
Electives[2]	2-0-2	2-0-2	2-0-2
Totals	X-X-17	X-X-16	X-X-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	3-0-3	....
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
PHYS 2122-3 Electromagnetism, Optics and Modern Physics	4-3-5	4-3-5	....
TEX 3400 Computer Applications in Textiles	....	....	2-3-3
TEX 2180 Textile Manufacturing Processes I	0-3-1	....	....

Course	1st Q.	2nd Q.	3rd Q.
TEX 4200 Fiber Science	....	3-0-3	....
ENGL 3023 Written Communication	....	....	3-0-3
Electives Humanities/ Social Science/ Modern Language	3-0-3	3-0-3	3-0-3
Electives[2]	....	....	6-0-6
Totals	15-6-17	18-3-19	14-3-15

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 3301 Mechanics of Deformable Bodies	5-0-5	....	....
ME 2212 Materials Science	....	3-0-3	....
ME 3720 Thermodynamics	4-0-4	....	....
ISYE 3749 Elementary Quality Control	....	....	3-0-3
TEX 4751 Polymer Science and Engineering II	....	....	3-0-3
TEX 4305 Chemical Preparation and Finishing of Textiles	....	....	3-0-3
TEX 4201-2-3 Mechanics of Fibrous Structures I, II, III	3-0-3	3-0-3	3-0-3
TEX 3600 Elementary Heat and Mass Transfer	....	3-3-4	....
TEX 2181-2 Textile Manufacturing Processes II, III	0-3-1	0-3-1	....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2]	....	3-0-3	3-0-3
Totals	15-3-16	15-6-17	18-0-18

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CE 3053-4 Fluid Mechanics I, II	....	3-0-3	3-3-4
EE 3725 Electrical Circuits and Fields	2-3-3	....	....
EE 3726 Elementary Electronics	....	2-3-3	....
EE 3727 Electric Power Conversion	....	....	2-3-3
TEX 4306 Dyeing and Printing	....	3-3-4	....
TEX 4420 Analysis of Textile Materials	3-3-4	....	....
ISYE 4725 Engineering Economy	....	3-0-3	....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 3480-1 Textile Manufacturing Processes IV, V	0-3-1	0-3-1	....
TEX 3984 Problems in Textile Management II	....	....	0-3-1
TEX 4901[3] Special Problems	....	0-3-1	0-3-1
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2]	3-0-3	....	3-0-3
Totals	12-9-15	15-12-19	12-12-16

[1]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[2]Twelve hours of electives must be approved by the department. Six must be humanities/social science/modern language. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.
[3]TEX 4481-2 can be substituted for TEX 4900-1.

Program for the Bachelor of Science in Textiles Degree

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
ENGL 1001-2-3 Analysis of Literature	3-0-3	3-0-3	3-0-3
MATH 1711-2-3 Mathematics for Management I, II, III	5-0-5	5-0-5	5-0-5
TEX 1100 Introduction to Textile Engineering	....	3-0-3	....
TEX 2103 Yarn Processing	....	....	3-0-3
ICS 2250 Technical Information Resources	....	....	1-0-1
Electives[1] Physical Education	X-X-2	X-X-1	X-X-1
Electives[2]	2-0-2	2-0-2	2-0-2
Totals	X-X-17	X-X-19	X-X-15

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 211 1-2-3 Physics	4-0-4	4-0-4	4-0-4
ENGL 3023 Written Communication	....	....	3-0-3
ECON 2000-1 Economic Principles and Problems	....	3-0-3	3-0-3
EGR 1170 Introduction to Visual Communications and Engineering Design I	2-3-3	....	....
TEX 2104 Yarn Processing II	3-0-3	....	....
TEX 3110 Woven Structures I	....	3-0-3	....
TEX 3112 Knit Fabrics	....	....	3-0-3
TEX 2180-1-2 Textile Manufacturing Processes I, II, III	0-3-1	0-3-1	0-3-1
Electives[2]	6-0-6	6-0-6	3-0-3
Totals	15-6-17	16-3-17	16-3-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
TEX 3122 Structures of Organic Polymers	3-0-3	....	....
TEX 4305 Chemical Preparation and Finishing of Textiles	....	3-0-3	....
TEX 4306 Dyeing and Printing	....	....	3-3-4
TEX 3113 Nonwoven Fabrics	3-0-3	....	....
TEX 3400 Computer Applications in Textiles	....	....	2-3-3
MGT 2000-1 Accounting I, II	3-0-3	3-0-3	....
MGT 3060 Financial Management	....	....	3-0-3
MGT 3300 Marketing I	3-0-3	....	....
TEX 4200 Fiber Science	....	3-0-3	....
ISYE 3749 Elementary Quality Control	....	....	3-0-3
TEX 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
TEX 3483-4 Problems in Textile Management I, II	0-3-1	0-3-1	....
Electives[2]	3-0-3	6-0-6	3-0-3
Totals	15-6-17	15-6-17	14-9-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
TEX 4420 Analysis of Textile Materials	3-3-4	....	....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1

Course	1st Q.	2nd Q.	3rd Q.
TEX 4100 Textile Management Decision-Making	....	2-3-3	....
TEX 4101 Planning and Control in Textile Production Systems	....	....	3-0-3
PSY 4401 Industrial Psychology	....	....	3-0-3
MGT 4200 Industrial Relations	....	....	3-0-3
ISYE 3115 ISYE Measurements	3-0-3	....	....
MGT 3150 Industrial Management Principles	....	3-0-3	....
TEX 3485 Problems in Textile Management III	0-3-1	....	....
TEX 4480 Problems in Production Supervision	0-3-1	....	....
Elective Either TEX 4481-2, Advanced Problems in Textile Management and Production Innovation or TEX 4900-1, Special Problems	....	0-3-1	0-3-1
Electives[2]	6-0-6	6-0-6	6-0-6
Totals	13-9-16	12-6-14	16-3-17

[1]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation for freshman physical education requirements for both men and women.

[2]Twelve hours of electives must be approved by the department. Twenty-one must be humanities/socials science/modern language electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

Program for Bachelor of Science in Textile Chemistry

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2[1] General Chemistry	4-3-5	4-3-5	....
CHEM 2113 Chemical Principles	....	....	3-3-4
TEX 1100 Introduction to Textile Engineering	....	3-0-3	....
ENGL 1001-2-3 Analysis of Literature	3-0-3	3-0-3	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ICS 2250 Technical Information Resources	....	....	1-0-1
Electives[2] Physical Education	X-X-2	X-X-1	X-X-1
Electives[3]	2-0-2	2-0-2	2-0-2
Totals	X-X-17	X-X-19	X-X-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381-2 Organic Chemistry Laboratory	....	0-6-2	0-6-2
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
PHYS 2121 Particle Dynamics	4-3-5	....	....
PHYS 2122 Electromagnetism	....	4-3-5	....
PHYS 2123 Optics and Modern Physics	....	....	4-3-5
ENGL 3023 Written Communication	....	....	3-0-3
EGR 1170 Visual Communication and Engineering Design I	2-3-3	....	....

Course	1st Q.	2nd Q.	3rd Q.
TEX 3400 Computer Applications in Textiles	....	....	2-3-3
Electives[3]	3-0-3	3-0-3	....
Totals	17-6-19	15-9-18	12-12-16

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 3412-3 Physical Chemistry	3-0-3	3-0-3	....
CHEM 3481 Physical Chemistry Laboratory	....	0-6-2	....
ISYE 3749 Elementary Quality Control	....	....	3-0-3
TEX 4310[4] Textile Instrumental Analysis	....	....	2-3-3
TEX 3600 Elementary Heat and Mass Transfer	....	3-3-4	....
TEX 4750-1 Polymer Science and Engineering I, II	....	3-0-3	3-0-3
TEX 4200 Fiber Science	3-0-3	....	....
TEX 4300 Chemistry and Chemical Processing of Fibers and Textiles I	....	....	3-0-3
TEX 2180 Textile Manufacturing Processes I	0-3-1	....	....
Electives[3]	9-0-9	6-0-6	3-0-3
Totals	15-3-16	15-9-18	14-3-15

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
TEX 4420 Analysis of Textile Materials	3-3-4	....	....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 4301 Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	....	....
TEX 4302 Textile Finishing Processes	....	3-0-3	....
TEX 4503 Science of Color	....	3-0-3	....
TEX 4201-2 Mechanics of Fibrous Structures I, II	3-0-3	....	3-0-3
TEX 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
TEX 4900-1[5] Special Problems	....	0-3-1	0-3-1
Electives[3]	3-0-3	6-0-6	12-0-12
Totals	13-6-15	13-6-15	16-6-18

[1]CHEM 1111-2 can be substituted for CHEM 1101-2.
[2]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[3]Fifteen hours of electives must be approved by the department. Twenty-seven hours must be humanities/social science/modern language electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.
[4]CHEM 4201 can be substituted for TEX 4310.
[5]TEX 4480-1 can be substituted for TEX 4900-1.

Appendix 2

AE 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: senior standing.
Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as ESM 4760, ME 4760.

AE 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: AE 4760 or equivalent.
Continuation of AE 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as ESM 4761, ME 4761.

AE 6760. Engineering Acoustics I
3-0-3. Prerequisite: consent of school.
Introductory analytical methods, stochastic processes, the wave equation in a compressible fluid, and problems in the radiation of sound. Also taught as ESM 6760 and ME 6760.

AE 6761. Engineering Acoustics II
3-0-3. Prerequisite: AE 6760.
Sound reflection and refraction, scattering and diffraction, sound radiation, and duct acoustics. Also taught as ESM 6761 and ME 6761.

AE 6762. Engineering Acoustics III
3-0-3. Prerequisite: AE 6761.
Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics. Also taught as ESM 6762 and ME 6762.

AE 6763. Noise Reduction and Control (Industrial Applications)
3-0-3. Prerequisites: AE 4760 or equivalent and 6760.
Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as ESM 6763 and ME 6763.

CHE 4414. Air Pollution Control
3-0-3.
Application of mass transfer principles of the design of pollution control systems utilizing adsorption, absorption, filtration, and precipitation. Other topics are process optimization, fuel pretreatment.
Text: At the level of Work and Warner, *Air Pollution—Its Origin and Control.*

CHE 6613. Technology of Fine Particles
3-0-3. Prerequisite: CHE 3301 or consent of school.
An examination of the properties of finely divided materials. Size, surface, pores are treated in relation to reactivity, absorptivity, catalytic behavior, and process engineering operations.
Text: At the level of Allen, *Particle Size Measurement.*

CE 4148. Application of Microbiology in Environmental Engineering
3-0-3.
Introduction to fundamental and applied microbiological principles in environmental engineering field with emphasis on microbial growth and metabolism in biological processes.

CE 6124. Air Pollution Measurements and Control
3-3-4. Prerequisite: consent of school. Fall quarter.
Analysis of air pollution problems of cities and industries, methods of evaluating the problems. Description, design, and use of air sampling equipment.

EE 4028. Audio Engineering
3-0-3. Prerequisites: EE 3270, 3310.
An introduction to the application of the tools of electrical engineering to the detection, measurement, processing, recording, and reproduction of audio frequency signals. Basic principles of sound. Microphones. Loudspeakers. Power amplifiers. Disk phonograph systems. Magnetic tape systems. Broadcast audio. Audio signal processing. Acoustical instrumentation.

EE 4041. Illumination Engineering
3-0-3. Prerequisites: PHYS 2123, EE 3310.
An introduction to interior and exterior lighting design.Basic topics considered are light, sight, color, photometry, illumination, luminaires, and sources.

EE 4751. Laser Theory and Applications
3-0-3. Prerequisite: PHYS 2123.
Principles of laser operations. Types of lasers. Survey lectures on the applications of lasers to various fields. Course intended for both EE and non-EE majors. Also taught as PHYS 3751.

ESM 6461. Biosolid Mechanics
3-0-3. Prerequisites: ESM 3301 or equivalent, MATH 2309 or equivalent, ESM 4351 or equivalent.
Mechanics as applied to living tissues. Bioviscoelastic solids. The constitutive equations for blood vessels, muscles, cartilage, bone, and other tissues.

HS 6340. Health Planning Techniques
3-0-3. Prerequisites: HS 6001, ISYE 6739.
Methods of group-consensus formation, goal setting and health needs assessment. Coverage includes Delphi and nominal group processes, patient-origin studies, accessibility analysis and decision procedures.

ISYE 3105. Organizational Structures
3-0-3.
The organizational elements, activities, and structures within which an industrial engineer functions.

ISYE 3113. Physiological and Biomechanical Analysis of Work
3-0-3. Prerequisite: ISYE 3010.
Techniques of data collection and analysis for effective man-power oriented tool and work place design.

ISYE 4090. Legal and Ethical Phases of Engineering
3-0-3. Prerequisite: senior standing or consent of school.
Introduces the engineer to the ethical, legal, and professional attitudes to be encountered in the future working environment. Includes business, patent, and copyright law considerations.

ISYE 4103. Management Information and Control Systems
3-0-3. Prerequisites: ISYE 4101.
Principles of the analysis and design of management information and control systems—especially those involving electronic data processing.

ISYE 4725. Engineering Economy
3-0-3. Prerequisite: sophomore standing. Not available to ISYE students or students with credit for ISYE 4726.
Fundamental principles and basic techniques of economic analysis of engineering projects including economic measures of effectiveness, time value of money, cost estimation, breakeven and replacement analysis.

ISYE 6101. Modern Organizations
3-0-3.
A comprehensive study of the theories of industrial organization with particular emphasis on analyzing, evaluating and integrating organizational activities.

ISYE 6103. Organizational Decision-Making
3-0-3. Prerequisites: ISYE 6101, 6734.
A course integrating behavioral findings with mathematical models of the decision process. The major focus is on these processes in organizational settings.

ISYE 6107. Management of Improvement
3-0-3.
Concepts of the management of improvement endeavors, strategies and tactics for achieving continuous improvement within organizations. Theoretical bases and approaches to encourage innovation are studied.

ISYE 6218. Work Systems Design
3-0-3. Prerequisite: consent of school.
Advanced study of the design of work systems with emphasis on the human operator and that role in the work system.

ISYE 6219. Human Factors Engineering
3-0-3.
Application of information on human capabilities and limitations in the design process. Design problems are used to aid understanding of application of human factors data.

ISYE 6220. Work Physiology
3-0-3.
An evaluation of the various factors affecting human physical performance in the industrial environment. Topics: anthropometry, biomechanics, energy expenditure, heat stress, fatigue, training, strength.

ISYE 6221. Man-Machine Control Systems
3-0-3. Prerequisite: consent of school.
An introduction to the application of systems theory and methodology to the analysis and design of man-machine control systems.

ISYE 6225. Advanced Engineering Economy
3-0-3. Prerequisites: ISYE 3025, 3131.
Advanced engineering economy topics, including measuring economic worth, economic optimization under constraints, analysis of economic risk and uncertainty, foundations of utility theory.

ISYE 6739. Experimental Statistics
4-0-4. Prerequisite: MATH 2308.
An introduction to the application of statistics. Topics include probability concepts, sampling distributions, point and interval estimation, hypothesis testing, multiple linear regression, analysis of variance. Not available for degree credit to ISYE students.
Text: at the level of Hines and Montgomery, *Probability and Statistics.*

ME 3734. Environmental Technology in Architecture I
3-0-3. Prerequisite: PHYS 2113 or 2123. Not for ME students.
Needs of modern structures. Water supply and drainage. Fire protection. Environmental comfort. Design heat load calculations. Generation, transport, and distribution of heat with associated costs.

ME 3735. Environmental Technology in Architecture II
2-3-3. Prerequisite: ME 3734. Not for ME students.
Effects of solar energy. Cooling load estimates. Air conditioning systems. Delivery methods. Energy management, conservation, and total energy systems. Latest topics in environmental control.

ME 4186. Biomechanical Design*
3-3-4. Prerequisite: ME 4445 or equivalent.
Design of systems utilizing human operator dynamics in the loop. Biological systems treated as structures, power sources and information systems, operator modeling.

ME 4318. Thermal Systems Analysis and Design
4-0-4. Prerequisites: ME 3324, 4344, 4183; ISYE 4725.
Analysis, design, and optimization of thermal systems and components with examples from such areas as power generation, refrigeration, and propulsion. Energy conservation schemes, total energy systems and their characteristics.

ME 4319. Thermoeconomic Design*
3-0-3. Prerequisite: ME 4318.
Design via synthesis and optimization of systems, components, and subcomponents modeled from thermal phenomena or their direct analogs while considering constraints from cost, size, weight, government regulations, and other such factors.

ME 4321. Principles of Air Conditioning*
3-3-4. Prerequisites: ME 3324, 4344 or consent of school.
Psychrometric principles. Thermal comfort. Load estimates. Environmental control. System design using load wedge and supply area concepts. Experiments to determine components and system performance.

ME 4343. Heating, Ventilating, and Air Conditioning Design*
3-0-3. Prerequisite: ME 4321.
Sizing of equipment for environmental control. Design of transportation and delivery systems. Energy recovery schemes. Total energy concepts and design features.

ME 6332. Heat Transfer I
3-0-3. Prerequisite: ME 4344 or consent of school.
Conduction-steady state and transient, one and multi-dimensional geometries. Emphasis on analytical methods-exact and approximate, on numerical and graphic techniques.

ME 6333. Heat Transfer II
3-0-3. Prerequisite: ME 6332 or consent of school.
Convection-forced and free, in laminar and turbulent, internal and external flows. Analogy between momentum and heat transfer. Scaling laws and partial modeling.

ME 6334. Heat Transfer III
3-0-3. Prerequisite: graduate standing.
Radiation-electrodynamics, radiation optics, photon gas concept, black body radiation, surface characteristic, exchange in enclosures, radiation through continua, experimental methods.

ME 6370. Thermal Environmental Control
3-0-3. Prerequisite: consent of school.
Thermodynamic relations of moist air. Air conditioning processes. Environmental systems fo: thermal comfort. Direct and indirect contact transport processes.

NE 3110. Nuclear Radiation Detection
2-6-4. Prerequisite: PHYS 3001.
A laboratory introduction to the principles and characteristics of basic detectors for nuclear radiations and the electronic systems associated with them.

HP 4412. Principles of Health Physics
3-0-3. Prerequisite: PHYS 3001 or HP 4411.
Course emphasizes the biophysical basis of radiation protection and the development of protection criteria.

HP 4413. Applied Health Physics
3-3-4. Prerequisite: HP 4412 or consent of school.
Topics covered include personnel monitoring, bioassay, air sampling and respiratory protection, radiation surveys of nuclear reactors, accelerators, and X-ray installations.

HP 4440. Effect of Nonionizing Radiation and Protection Standards
3-0-3. Prerequisites: consent of school and HP 4412 or equivalent.
A study of methods of production and control of exposure to nonionizing radiations and a review of effects of human exposure and of the radiation protection standards.

HP 6800. Industrial Health Protection Survey
3-3-3.
A survey of the major physical and chemical hazards in the industrial environment emphasizing recognition, monitoring technology, engineering control methodology, best practice, and current regulations.

TEX 4480. Problems in Production Supervision
0-3-1. Prerequisites: TEX 2180-1-2, 3480-1.
Supervision of the student operated enterprise production operations. Solving day to day problems in logistics, personnel relations, and manufacturing technology.

OCCUPATIONAL SAFETY AND HEALTH TRAINING IN

THE ENGINEERING COLLEGE AT GEORGIA TECH

Final Report

Submitted to:

The Divison of Training and Manpower Development
of the National Institute for Occupational
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Project Officer: Mr. John Talty

Submitted by:

The Georgia Institute of Technology
School of Nuclear Engineering and Health Physics
Author: Dr. John Carden

3.0 Results from Interviews

3.1 Background

The eleven degree granting schools making up the College of Engineering at Georgia Tech are listed in Table 1 along with their percentage of the undergraduate population during Fall Quarter 1981. The total undergraduate engineering enrollment during that quarter was 6,580 students.

A short description, taken from the 1982-83 General Catalogue, of the undergraduate program of each school including the curriculum is included in Appendix 1. It should be noted that Nuclear Engineering and Health Physics offers undergraduate degrees in both fields and Textile Engineering offers degrees in three areas: textile chemistry, textiles, and textile engineering. Thus, the College has a total of 14 programs offering Bachelor's degrees.

School	Percentage of Engineering College Enrollment (Fall 1981)
Aerospace Engineering	8.4
Ceramic Engineering	0.7
Chemical Engineering	12.9
Civil Engineering	8.5
Electrical Engineering	27.2
Engineering Science and Mechanics	1.4
Health Systems	1.0
Industrial and Systems Engineering	11.8
Mechanical Engineering	20.1
Nuclear Engineering and Health Physics	2.0
Textile Engineering	1.3
Undecided (freshmen)	4.8

TABLE OF CONTENTS

Occupational Safety & Health Training in
the Engineering College at Georgia Tech

1.0 Perspective

The scope of health and safety related activity and investment changed dramatically after the passage in 1970 of the Occupational Safety and Health Act. By 1980 capital expenditures by industry for safety and health had reached $4 billion dollars.

While this investment may seem high, it pales in comparison to the cost of accidents to industry and the workers involved. In 1980, the National Safety Council estimated this cost to be 30.2 billion dollars amounting to an amazing 310 dollars per worker [1]. The human suffering associated with work related accidents must also be considered. In 1980, 13,000 workers were killed and 2,200,000 disabling injuries were reported[1].

With this astronomical cost in suffering and dollars in mind, it is imperative to ask how well the money being invested in health and safety is being used. The answer seems to be, not as well as it could . The reason for this is twofold: First, much of the investment is in retrofits, after start-up modifications necessitated by poor design. Most engineers responsible for design have not been trained in occupational safety and health and are unfamiliar with the associated regulations, thus such considerations are not incorporated. The cost of comparable control equipment, included at the design stage, would be much less. Second, much of the control equipment, designed in or retrofit, is ineffective. This is largely due to inadequate training of the professionals involved in its development.

The engineer has a central role to play in the protection of the work force. The problem, reduced to basics, requires that health professionals determine the hazard associated with a material or energy field, after which, it is up to the engineer to design a process or control system capable of protecting the worker while getting the job done. The training of engineers to adequately fulfill this role would improve worker protection while reducing the associated costs. Accepting this role represents a responsibility and challenge, as well as an economic opportunity.

A former Director of OSHA, Dr. Morton Corn, interpreted the General Duty Clause of the Occupational Safety and Health Act in terms of the responsibility of engineers as follows:

> "Under Section 6a of the Occupational Safety and Health Act, the General Duty Clause, every engineer in responsible charge of a facility must treat the people and community in his (or her) responsible charge in accordance with the current state of knowledge. If anything goes wrong in the facility, he or she will be held to this standard of performance, not only to the specifics of a legal standard, but the general duty to the community and to the people who work in that facility (2)."

Dr. Corn, as have others[3], indicates that defensible performance by an engineer is determined by the extent to which performance reflects the current state of knowledge. This is as true for worker protection as it is for process or equipment design.

Recognition of the need to start engineers off in their profession with adequate training in occupational safety and health has guided a number of premier engineering schools to introduce such courses in their curricula. The National Institute for Occupational Safety and Health has also played a supporting role in this development[4]. Engineering Schools with such courses include Purdue University, Ohio State University and the University of California at Irvine.

The role of the Georgia Institute of Technology as an important national resource for the education of engineers requires that it investigate this aspect of the educational process. The study reported here looked at ways in which occupational safety and health training could be integrated into the curricula of the Engineering College at Georgia Tech with the objective of reaching the largest possible number of students.

Occupational Safety and Health Training

in the Engineering College at Georgia Tech

2.0 Introduction

During August, 1982, a survey of faculty members and administrators of the College of Engineering was carried out. The survey consisted of personal interviews performed by the author. The following information was sought during the interview:

1. occupational Safety and Health (OS&H) topics of particular relevance to the discipline of the interviewee
2. the present degree of coverage of important OS&H topics in the interviewee's school
3. courses currently in the curriculum with potential for inclusion of OS&H information
4. insight into past and current problems which have limited the inclusion of OS&H information in the college's curricula
5. an evaluation of the value and potential for success of a college wide video based modular course providing an introduction to OS&H concepts, issues and materials
6. other suggestions for the delivery of OS&H training within the interviewee's school

The information obtained on each of these questions is presented in section 3. Section 4 contains comments from a progress review meeting held at NIOSH in September, 1982, and Section 5 presents two scenarios for increasing OS&H training for undergraduate engineering students.

Table 1. The degree granting schools making up the Engineering College at Georgia Tech and the percentage of undergraduate students enrolled.

Interviewees were chosen based on the author's awareness of interest in OS&H, a recommendation from the Associate Dean of Engineering, a recommendation by another faculty member, or the research and academic interest of a faculty member as indicated in the "Register of Professional Personnel of the College of Engineering." Seventeen teaching faculty members were interviewed in person and two were interviewed by phone.

3.2 Discipline Specific OS&H Topics

For the purpose of this study it seems reasonable to divide OS&H topics or skills into two groups; those of direct professional importance and those of general importance. Direct professional importance covers those topics and skills which a graduate engineer might reasonably be expected to have mastered in sufficient depth to be able to solve an OS&H problem. For instance, a mechanical engineer could reasonably be expected to be able to design an industrial ventilation system, thus industrial ventilation is a topic of direct professional importance in mechanial engineering. General importance covers those topics and skills to which an engineer needs to be introduced to create awareness, but generally involves problems which the engineer himself/herself would not be expected to solve. For example, an industrial engineer might note a probable noise exposure problem in a production area, but he/she would likely request an evaluation by an industrial hygienist and look for a solution from a mechanical engineer.

In order to deal in a uniform way with the potential problem of a faculty member being essentially unaware of OS&H aspects of his/her discipline, a list of typical topics was generated (see Table 2) and taken to each interview. The list was not shown to the interviewee and was only used when necessary to stimulate thinking along appropriate lines.

The results of this portion of the study are presented school by school in the material that follows.

1. Common Industrial illnesses
2. Ergonomics and human factors
3. Heat stress
4. Noise and vibration
5. Nonionizing radiation
6. Ionizing radiation
7. Lighting and illumination
8. Ventilation
9. Personal protective devices
10. Applied industrial toxicology
11. Environmental monitoring
12. Sanitation
13. OS&H literature
14. Sources of services and assistance
15. Legislative and regulatory requirements
16. OS&H program structure and management
17. OS&H program costs and payback

18. Facility layout and materials handling

19. Emissions control

20. Fire and life safety

Table 2. Typical OS&H topics.

One or two faculty members were interviewed in each school, thus the ideas and conclusions reported could reflect uncompensated personal bias. Nevertheless the information obtained seems adequate for the overall purpose of this study.

3.2.1 Aerospace Engineering (AE)

One faculty member from this school was interviewed. He indicated that the technical area generally dominated by AE graduates is air frame design. Areas shared with other disciplines include engine design and control system layout and design. It was not clear that any major professional responsibilities for OS&H exist for AE's, but there are a number of general areas of importance including shop safety, noise, vibration, human factors, heat stress, ionizing radiation and nonionizing radiation.

3.2.2 Ceramic Engineering (CERE)

One faculty member from this school was interviewed. Bachelors level graduates from this school are involved in all aspects of the glass and ceramics industry. Professional interests identified include heat stress, noise and vibration, ventilation, personal protective devices and legislative and regulatory requirements. General interests identified include common industrial illnesses, OS&H program costs and paybacks, nonionizing and ionizing radiation, lighting and illumination, industrial safety, applied industrial toxicology, OS&H program structure and management, sources of services and assistance, and environmental monitoring.

3.2.3 Chemical Engineering (ChE)

Two faculty members from this school were interviewed. Typically ChE's are found in a wide range of positions in the chemical process industries from process design and development to operations and management. Areas of direct professional importance include facility layout, environmental monitoring, and emissions control. All of the topics in Table 2 are of general importance because of the high probability of operations or management responsibilities.

3.2.4 Civil Engineering (CE)

Two faculty members from this school were interviewed. The Bachelors program in CE provides training for specialization in a broad spectrum of areas spanning structures and construction to environmental engineering, surveying, soil mechanics, hydrology and transporation. The wide range of potential activities of graduates makes identification of specific major professional responsibilities difficult. The following general responsibilities were identified: common industrial illnesses, ergonomics, heat stress, noise and vibration, nonionizing radiation, ionizing radiation, personal protective devices, applied industrial toxicology, sanitation, environmental monitoring, OS&H program structure and management, and legislative and regulatory requirements.

3.2.5 Electrical Engineering (EE)

Two faculty members from this school were interviewed. The undergraduate EE program covers a number of areas with approximately 70% of our students currently specializing in some area of digital electronics which probably will not lead them into equipment design or device fabrication. It is felt that these students do not require any training in OS&H. The remaining 30% specialize in areas such as physical electronics and power engineering with associated risk of exposure to occupational hazards. Major professional responsibilities were not identified, but general responsibilities include heat stress, noise and vibration, nonionizing radiation, lighting, and illumination, ventilation, personal protective devices, applied industrial toxicology, and legislative and regulatory requirements.

3.2.6 Engineering Science and Mechanics (ESM).

Two faculty members from this school were interviewed. ESM emphasizes the fundamentals underlying engineering practice and as a result graduates of this school are often involved in the development of processes or equipment for which no design criteria exist. Major professional responsibilities may include human factors and noise and vibration while general responsibilities may include nonionizing radition, ionizing radiation, lighting, illumination, ventilation, applied industrial toxicology and legislative and regulatory requirements.

3.2.7 Health Systems (HS)

One faculty member from this school was interviewed. HS prepares students for the planning and operation of health care delivery systems. While no major professional responsibilities were identified, the general responsibilities associated with operations and management could involve any of topics covered in Table 2.

3.2.8 Industrial and Systems Enginering (ISyE)

One faculty member from this school was interviewed. Bachelors level graduates from this school are involved in a wide range of operations oriented activities. Major professional interests identified include ergonomics and human factors, industrial safety, OS&H program structure and management, and the providing of services and assistance with some OS&H related problems. General interest include common industrial illnesses, OS&H program costs and paybacks, heat stress, noise and vibration, lighting and illumination, ventilation and personal protective devices.

3.2.9 Mechanical Engineering (ME)

Two faculty members from this school were interviewed. Major professional areas identified include ergonomics, human factors, noise, vibration and ventilation. General responsibilities may involve all of the topics of Table 2 with the exception of sanitation.

3.2.10 Nuclear Engineering and Health Physics (NEHP)

One nuclear engineering faculty member was interviewed and the author contributed input regarding health physics. Nuclear engineering contributes heavily to the design and operation of nuclear power generating facilities and the facilities associated with nuclear fuel cycles. Health Physics provides expertise in interactions between ionizing radiation and biological systems. Both NE and HP graduates have a professional interest in ionizing radiation and personal protective devices. NE graduates are likely to have a general requirement for information concering heat stress, noise and vibration, ventilation, applied industrial toxicology and fire and life safety. HP graduates are at times called upon to provide some basic industrial hygiene services, thus all of the topics in Table 2 are at least of general interest.

3.2.11 Textile Engineering (TEX)

Two faculty members from this school were interviewed. This school offers undergraduate programs in three areas: textile engineering, textile chemistry, and textiles. Familiarity with OS&H regulatory requirements was identified as a major professional responsibility and all of the topics in Table 2 were identified as probable general responsibilities. Air borne particulates such as cotton dust is another issue identified as particularly important to TEX graduates.

3.2.12 Summary of Issues Identifed

Table 3 lists the topics identified as relevant to their discipline by the faculty members interviewed.

TOPICS	SCHOOL: AE	CERE	ChE	CE	EE	ESM	HS	ISyE	ME	NE	TEX
Common industrial illness		G	G	G			G	G	G	G	G
Ergonomics and human factors	G		G	G		P	G	P	P	G	G
Heat stress	G	P	G	G	G		G	G	G	G	G
Noise and vibration	G	P	G	G	G	P	G	G	P	G	G
Nonionizing radiation	G	G	G	G	G	G	G		G	G	G
Ionizing radiation	G	G	G	G		G	G		G	P	G
Lighting and illumination		G	G		G	G	G	G	G	G	G
Ventilation		P	G		G	G	G	G	P	G	G
Personal protective devices		P	G	G	G		G	G	G	P	G
Applied industrial toxicology		G	G	G	G	G	G		G	G	G
Environmental monitoring		G	P	G			G		G	G	G
Sanitation			G	G			G			G	G
OS&H literature			G				G		G	G	G
Sources of services and assistance		G	G				G	G	G	G	G
Legislative and regulatory requirements		P	G	G	G	G	G		G	G	P
OS&H program structure and management		G	G	G		P	G		G	G	G
OS&H program costs and payback		G	G			G	G		G	G	G
Facility layout and materials handling			P				G		G	G	G
Emissions control			P				G		G	G	G
Fire and life safety		G	G			P	G		G	G	G
Shop safety*	G										
Airborne particulates*											P

Table 3. Topics identified by interviewees as important to students in their school. P denotes professional importance, G denotes general importance.

* identified by school indicated

3.3. Current Coverage of OS&H Topics

Prior to the interviews the course descriptions given in the 1982-83 General Catalogue were searched to identify courses which might contain or appeared to have a potentital for inclusion of OS&H topics. The courses falling into this category are listed, along with the catalogue description, in Appendix 2. This material was used as the starting point for discussion during the interviews.

3.3.1 Aerospace Engineering

Two undergraduate (AE 4760 and 4761) and four graduate courses (AE 6760, AE 6761, AE 6762, AE 6763) in accoustics are multiply listed in this school as well as in ESM and ME. The first two courses are senior electives. Undergraduates are not generally allowed to take the upper level (6000) courses. The 4000 level courses have not been taught recently because of demands on the faculty to teach other courses in the curriculum. The 6000 level courses have not been offered for the past three years for the same reason. The OS&H related training currently provided in this school is generally restricted to information given to students prior to performance of exercises assigned in teaching laboratories. The school's shop, which is used by students as well as professionals, has an established training and "check out" system which emphasizes safety.

3.3.2 Ceramic Engineering

Some OS&H information is provided at relevant places in existing courses. Examples include a discussion of the hazard associated with respirable α-quartz as a part of glass compounding and a discussion of As_2O_3 exposure during bubble removal. Personal protective devices and safe practices are discussed as a part of teaching laboratory preparation and prior to plant visits. Ventilation and air handling arestressed because of their importance in ceramics production. The general philosophy associated with OS&H training emphasizes the practical i.e., adequate worker protection must be provided in an economically acceptable manner.

3.3.3 Chemical Engineering

ChE 4414 ("Air Pollution Control") apparently does not contain material directly related to OS&H. ChE 6613 does include a short discussion of the effects of particle size on deposition in the air ways of the respiratory system.

3.3.4. Civil Engineering

A number of introductory OS&H topics are covered in two undergraduate courses: CE 4133 (Engineering Aspects of Environmental Health) and CE 4143 (Man and His Environment). The combined OS&H content of these courses is roughly as follows:

Topic	Contact Hours
Common Industrial Illnesses	1
Ergonomics & Human Factors	1
Heat Stress	1
Noise and Vibration	1
Nonionizing Radiation	4
Personal Protective Devices	½
Applied Industrial Toxicology	2
Sanitation	2
OS&H Program Structure and Management	½
Legislative and Regulatory Requirements	1

Both courses are electives with CE 4143 attracting approximately 70 students per year and CE 4133 attracting approximately 45 students per year. CE 4143 is one of two so called "sociotechnology" courses offered by schools in the Engineering College which can be counted toward the social sciences requirement for the bachelors degree.

3.3.5 Electrical Engineering

With the exception of safety information associated with laboratory exercises, no OS&H information as such is provided. It does appear, however, that information is provided which would be useful to a practicing engineer for solving some OS&H problems. For example, EE 4026 "Audio Engineering" provides information useful for the design of sound level measuring equipment and EE 4041 "Illumination Engineering" for the design of industrial lighting systems.

3.3.6 Engineering Science and Mechanics

OS&H information is not currently included in course materials to any significant extent. The comments in 2.3.1. concerning the multiply listed accoustics courses apply here as well.

3.3.7 Health Systems

OS&H information is not currently included in course materials to any significant extent.

3.3.8 Industrial and Systems Engineering

The major contribution to OS&H training is in the area of human factors. Relevant material is presented in ISyE 3113, 6218, 6219, 6220, and 6221. Applied statistical techniques useful for many OS&H applictions are taught in ISyE 6739.

3.3.9 Mechanical Engineering

While it appears that a number of courses might contain OS&H related information, the actual material presented tends to be more fundamental with little emphasis on such topics.

3.3.10 Nuclear Engineering and Health Physics

The undergraduate program does not contain any significant OS&H training. The graduate health physics program contains a required OS&H course (HP 6800, "Industrial Health Protection Survey"), but undergraduates do not take it.

3.3.11 Textile Engineering

TEX 2180, "Textile Manufacturing Processes I," provides some OS&H training in the form of a 3 hour lecture which introduces the OS&H issues paramount in textile manufacturing and a requirement that each student view the American Textile Manufacturers Institute audiovisual safety program (a series of slides narrated on cassette tape). The school did at one time offer a special topic course (has not been offered for the past few years) devoted to OS&H in the textiles industry with emphasis on the regulatory structure.

3.4 Potential Curriculum Modification to Provide Increased OS&H Coverage

Each interviewee was asked if courses currently in the curriculum could be modified to include additional OS&H information. The following related issues were also discussed:

1. ways of facilitating such a change
2. probable faculty response
3. factors which would impede such a change.

3.4.1 Aerospace Engineering

No specific courses were identified, but it was indicated that a number of topics were discused in the undergraduate curriculum which could be expanded to include related OS&H information (partial lectures, etc.). Bringing related OS&H information to the attention of the instructors would aid this process. Instructors would probably be cooperative, but their familiarity with the topics involved as well as their related personal experience would strongly impact on the extent of their participation.

3.4.2 Ceramic Engineering

No specific courses were identified. As indicated in 2.3.2 some OS&H information, which is specifically related to major topics in the curriculum, is already included and this approach could be expanded. The availability of appropriate current OS&H information would facilitate this process. This information needs to stress well documented health or safety risks and suggestions or remedies which can be demonstrated to provide a real return (in terms of worker protection, reduced liability exposure, etc.) for the industry involved. Information of this sort would contribute to an "engineering education" i.e., provide understanding of real problems and suggest solutions which facilitate production. Faculty response would be generally positive.

3.4.3 Chemical Engineering

ChE 4414 and ChE 6613 could possibly be modified to include additional relevant OS&H information. Three additional options were suggested for adding OS&H information. These included:

1. The inclusion of 1 or 2 OS&H lectures (3 hrs each) per quarter in the four required laboratory coures (ChE 3302, ChE 3303, transport phenomena, and ChE 3309, ChE 3310, unit operations).

2. Integrate 3 to 6 lectures (1 hr each) into ChE 4431 (Chemical Engineering Economics) and add a requirement for the inclusion of appropriate OS&H considerations in the design problem assigned in ChE 4434 (Plant Design).

3. The development of an equipment design course along the lines of ChE 4432 which emphasized OS&H related problems. This option would require the availability of a faculty member with a strong interest in the areas, a condition which does not exist at the moment.

It was indicated that the introduction of additional material could probably be achieved especially with the ready availability of relevant information, but that long term success hinged on the presence of a real academic interest on the part of the faculty. Without ongoing research the long term prospects for such an initiative are not bright.

3.4.4 Civil Engineering

OS&H related training, through elective courses in this School's undergraduate program, is the most comprehensive in the College. The student population in these courses is drawn from all of the Colleges of the Institute. Additional materials can be incorporated into these courses as relevant information becomes available to the instructors.

3.4.5 Electrical Engineering

The consensus here is that the courses in the required curriculum are already too crowded in terms of content. Senior Seminar was suggested as a possible home for one or two OS&H lectures.

3.4.6 Engineering Science and Mechanics

Relevant OS&H information could be built into existing courses. Information provided to instructors would assist this process.

3.4.7 Health Systems

HS 3118 (a facility design course) was suggested as a potential home for some relevant OS&H training. Assistance with identifying and obtaining information was cited as very important to the inclusion of OS&H materials in the HS curriculum.

3.4.8 Industrial & Systems Engineering

The content loading in most courses is high and the instructional staff has a heavy teaching load; factors which do not facilitate the restructuring of existing courses.

3.4.9 Mechanical Engineering

The situation is very similar to that in ISyE.

3.4.10 Nuclear Engineering and Health Physics

Three lectures (1hr each) could perhaps be devoted to relevant OS&H topics in NE 3211 (Elements of Nuclear Engineering). NE 4230 (Nuclear Engineering Design) might incorporate more comprehensive OS&H considerations into the problems assigned. HP 4412 (Principles of Health Physics) might be expanded to include some important nonradiation OS&H information. The availability of materials is important to success.

3.4.11 Textile Engineering

Increasing the OS&H content of existing courses is difficult because of high current material loading.

3.5. Introduction of a New OS&H Course

The interviewees were asked to comment on the possibility for the development by their school of an OS&H course. The reaction to this suggestion was universally negative for one or both of two reasons: no one on the school's faculty has sufficient interest or background to develop the course or the faculty is already so loaded with courses that such an assignment is not possible.

A second scenerio was presented to the interviewees for comment. The scenario centers around a new OS&H course prepared on a college-wide basis as a technical elective. The course would be developed by a committee made up of Engineering College faculty and other appropriate individuals. The course would be a one quarter, three credit-hour multiply listed course, offered by any school so choosing . The committee would develop the course content and choose instructors from the College to provide the lectures involved. These lectures and/or demonstrations would be video taped and the tapes would be used by the various schools when the course was offered. The video lectures would cover the OS&H topics deemed of general importance by the committee and a block of lectures (approximately 5) would be left open so that the course coordinator in the School could expand on material of particular importance in the School's discipline. Exams would be coordinated through the committee to facilitate student performance evaluation.

The response to this scenerio was generally positive with the faculty involved indicating a willingness to participate provided the associated demands on their time did not become excessive. The consensus was that advisors would probably encourage students to participate with the strength of this encouragement depending on the quality of the course and its success in transferring useful and valuable information. The course would, however, have to compete with electives related to other "burning" issues such as energy conservation in industry.

3.6 Other Suggestions for Integration of OS&H Training

It was suggested that guest lectures might be incorporated into some existing courses and that seminar speakers might be invited to discuss current issues in OS&H.

4.0 Consultation at NIOSH

Sections 1 and 2 of this report were presented on September 17, 1982 to NIOSH personnel. Three comments emerged from this meeting.

First, the Division's experience with video-base instruction has been discouraging in some cases. A degree of direct teacher involvement seems necessary to elicit the required student involvement.

Second, if a media-based course is to be developed, material "currently on the shelf" needs to be considered for inclusion. Such materials, if appropriate, could greatly reduce the time and effort required to develop the course.

Third, the methods of computer-aided instruction should be considered.

5.0 Promising Scenarios

In this section the information and recommendations obtained during the study are incorporated into two scenarios. One scenario deals with the development of a new elective course designed to reach a maximum number of undergraduate engineering students. The second scenario involves a less ambitious approach designed to facilitate the incorporation of OS&H topics into existing courses.

These scenarios do not deal with course content in detail. The study did not identify content as a major obstacle to acceptance and support of a widely available OS&H course. Indeed, most faculty members interviewed seemed quite willing to consider a proposed syllabus and to suggest improvements. Thus, course content would be set initially by making use of the information from the interview process described in Section 2 and incorporation of other important issues in OS&H program. The information bases developed in other programs such as that at Purdue[5] would be utilized. The content would then be periodically reviewed by faculty from the Schools involved to maintain its value and acceptance. Important considerations in treating the topics covered are attention to fundamentals and quantitative methods.

The major problems identified involve financial and personnel resources. These scenarios then are aimed at minimizing the demands on these resources without sacrificing instructional quality.

The first scenario is an Engineering College wide OS&H course. This scenario is ambitious, utilizing emerging educational techniques and requiring a substantial front end investment. Once in operation it should, however, provide high quality instruction at a low cost per contact hour. It should also serve as a model for the development of other courses and could perhaps be expanded via some type of network such as AMCEE (Association for Media-Based Continuing Education for Engineers) to reach a very large student population.

The second scenario is less ambitious and involves minimal front end and continuing costs. The students affected, material delivered, and effectiveness of the approach are less well defined than for the first scenario, but it could still substantially increase the OS&H exposure of both undergraduate and graduate students in engineering.

5.1 An OS&H Course for the Engineering College - Scenario 1

At this point it does not seem realistic to recommend a required OS&H course for the Schools in the Engineering College. This is due primarily to limited funds for instruction, heavy demands on faculty time, and limitations on the number of required hours in each School's curriculum. These factors must also be considered in any recommendation for a new elective course.

The following scenario attempts to maximize student involvement and interest while minimizing the ongoing demand for direct faculty involvement. Since the course must be an elective, a high level of student interest is essential if the course is to reach a significant number of students. The use of computer assisted instruction (CAI) should contribute significantly to both the interest of students and the efficient use of faculty resources.

5.1.1. Course Administration

The course is organized by a committee of Engineering College faculty and others deemed appropriate. This committee determines the course content, chooses the lecturers involved, approves the examinations, and sets the grading scale. The course is available to any School in the College, and those Schools offering the course do so under a number assigned by them.

5.1.2. Facilities

A classroom equipped with a video playback system is required as is access to an adequate number of computer terminals. Preparation of course materials requires a studio for video taping and facilities for editing and reproducing tapes. Appropriate software must be purchased or developed for the CAI component of the course.

5.1.3. Evaluation

Computer administered and scored examinations are utilized. Each student's performance is evaluated as is test item validity. Performance profiles will be used to determine the effectiveness of the instructional materials.

5.1.4. Course Structure

The course is divided into two blocks. The first and larger block (approximately 80%) consists of a survey of basic OS&H topics of relevance to engineers. The objective is to introduce concepts, develop awareness, and to identify sources which could be consulted later in practice if needed. All participating students would receive this block. The second block is unique to each discipline. Information is represented which is of particular value to the discipline of the School. For example, the School of Textile Engineering discusses health effects, monitoring strategies, and control technologies for airborne fibers while Nuclear Engineering and Health Physics discusses heat stress, hearing conservation, and work related psychological stress. This final section may also contain information about OS&H regulations specific to the discipline involved.

5.1.5. Structure of Instructional Units

A unit or lecture of approximately 50 minutes has one of two formats: a 30 to 35 minute video tape followed by a discussion led by an instructor, or a 50 minute session working with the computer. Lecturers are present during and after the video tape presentation. A packet of information is provided to the instructor for this purpose.

5.1.6. Course Delivery

The method of course delivery develops via an orderly evolutionary process. The initial offerings of the course utilize a single lecturer delivering the first block of material to a "large" class. The second block is then delivered by an appropriate lecturer from each School with participating students. The CAI element is present throughout. This phase allows debugging and a thorough evaluation of the concept and materials.

With a complete and well characterized course in hand, the individual Schools of the College may wish to take over the entire delivery function. It may also be advantageous to continue the option of a College wide offering to serve the students of Schools which, for whatever reason, do not choose to offer the course on their own.

5.2. Integration of OS&H Topics into Existing Courses - Scenario 2

A willingness was expressed by a number of faculty members to include OS&H materials in their courses provided appropriate information was made available to them. They expressed interest in and a recognition of the importance of OS&H, but pointed out that this is not their area of expertise and consequently they do not follow the associated literature in any depth unless an OS&H issue arises which poses a serious problem for their discipline (for example, concern over the carcinogenic activity of arsenic threatening the continued production of As_2O_3 in the US a serious problem for ceramic engineers involved in glass production).

The potential of this approach for increasing OS&H coverage is realized by establishing an active on campus clearing house for OS&H resources. The activities of this clearing house include:

1. identification of courses (including instructors) which could include OS&H materials;
2. notification of instructors of the existence of the clearing house;
3. acquisition of course outlines;
4. identification and transmission of current OS&H information;

5. identification and notification concerning audiovisual or other teaching aids;

6. identification and notification concerning the availibility of guest speakers;

7. development and execution of an evaluational instrument to assess the effectiveness of this scenario.

6.0 Conclusions and Resource Estimates

Clearly Scenario 1 is the more desirable option. It represents a program which should reach a large fraction of our engineering students with a well designed and controlled body of material. Content can be chosen to insure the efficient delivery of the most important concepts and information. Student performance and course quality can be carefully monitored. Course materials, once optimized can be easily updated and can be utilized in courses designed for off campus student populations.

The major problems associated with Scenario 1 are the high cost associated with development of the materials involved, the requirement for computer and video equipment, and the continuing cost associated with the purchase of computer time for student use during the course.

At Georgia Tech the requisite facility for preparation of high quality video taped lectures is available through the Center for Media Based Instruction. Two theaters equipped with video projection equipment are currently available for use during the developmental and shake-down stages of Scenario 1. Few Schools have their own video projection facilities at this time a facilities limitation which could set the pace at which the course could be taken over by the individual Schools of the College.

The Rich Computer Center can provide the hardware, software, and support necessary for development of the CAI component of the course and provide terminals for use by students. A very preliminary investigation of costs asssociated with Scenario 1 indicates that the overall cost is very sensitive to the details of the CAI component.

The following information about cost is provided to give some insight into potential problems (and possibilities). It must be kept in mind that this is not a proposal and does not in any way represent an offer to perform the tasks indicated. Cost estimates are based on information from knowledgeable individuals and not on firm quotations. For purposes of estimating cost it is assumed that the course is made up of 30 sessions, each 50 minutes in length. Two of these sessions are used for examinations, five for discipline specific materials and 23 for presentation of survey materials. Of the 28 teaching sessions 19 are video taped lectures, and 9 are CAI sessions. The cost of producing the video materials for one session is estimated at $85 (studio, editing and tape). The cost of developing the CAI materials for one session is estimated at $700 (choice of materials, programming, and connect time). In addition, the equivalent of one full time faculty member would be necessry to get the materials together in one quarter. Thus the total estimated cost of generating the materials is $18,000 exclusive of any indirect costs.

The cost of delivery of the course materials depends strongly on how the CAI is implemented. If Institute owned software, MultiTutor by Control Data Corporation (CDC), and terminals are used, the cost per individual session would be approximately $1. If Plato, a highly advanced and widely utilized training oriented software by CDC, is rented, termianals are leased and computer time is purchased from CDC the cost per individual session would be approximately $7. The advantages in using Plato include more advanced graphics, networking with other users with similar interests and a more advanced system for training. Using this system it may even be possible to simulate some laboratory exercises. A useful option may be to develop the required materials using MultiTutor and then to convert them to Plato. If a large number of students enroll, as we hope they will, the cost of the CAI component could become substantial.

A bright note in all of this is that we are discussing the development of a course with a potentially large national audience. A number of software companies including CDC have contributed to the development of software which they could then market. There is also some private sector interest in the development of combined video CAI course materials.

Following the one quarter full time effort to develop the course materials, the course should go through a 5 quarter optimization and evaluation phase. The total personnel requirements should be approximately one person year.

Scenario 2, while not having the potential of Scenario 1, could be of value in increasing OS&H exposure of both graduate and undergraduate students. Its impact would depend on many factors including targeting the right faculty members and the timeliness and quality of the information or other resources that could be provided. Implementation and testing of such a program would probably require two academic years involving a total 0.50 person year effort.

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Appendix 1

School of Aerospace Engineering

Daniel Guggenheim School of Aeronautics, Established in 1930

Director—Arnold L. Ducoffe; *Associate Director and Regents' Professor*—Robin B. Gray; *Regents' Professors*—Warren C. Strahle, Ben T. Zinn; *Professors*—Robert L. Carlson, James I. Craig, Howard D. Edwards, Don P. Giddens, Sathyanarayana V. Hanagud, John J. Harper, Wilfred H. Horton, James E. Hubbartt, Howard M, McMahon, G. Alvin Pierce, Edward W. Price, Lawrence W. Rehfield, James C. Wu; *Associate Professors*—Stanley C. Bailey, C. Virgil Smith, Jr.; *Assistant Professors*—Jechiel I. Jagoda, Spyridon G. Lekoudis.

General Information

The School of Aerospace Engineering prepares students at the bachelor's, master's, and doctoral levels for a career in vehicle engineering with primary emphasis on flight vehicles. The school is housed in three buildings having a floor space of 85,000 square feet with a majority of this space devoted to instructional and research laboratories.

Undergraduate Programs

The first two years focus on course work in the areas of chemistry, mathematics, physics, humanities, and social sciences. Aerospace disciplines and related engineering sciences are emphasized in the third and fourth years. The undergraduate curriculum is designed to provide each student with a general background for either industry or graduate school at the end of four years. The program stresses both the theoretical and experimental aspects of aerospace engineering.

A certain degree of specialization is available to undergraduate students through the proper choice of electives or certain substitutions for required courses or both, depending on the student's abilities and career objectives. These specialized disciplines are acoustics, aeroelasticity, aerospace vehicle design, bioengineering, experimentation and instrumentation, fluid dynamics of pollution, helicopters and V/STOL aircraft, propulsion, structural dynamics, structures and supersonic and hypersonic vehicles.

A pre-med track is available to undergraduate students. This requires an additional academic year of chemistry and one academic year of biology. Students may substitute these courses for the electives and for certain required courses in the present curriculum.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Elective EGR 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives[1]	X-X-3	X-X-3	....
CHEM 1101-2 Inorganic Chemistry	4-3-5	4-3-5	....
MATH 1307-8-9[2] Calculus, I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121[2] Physics	....	....	4-3-5
Electives[3] Humanities/Social Science/ Modern Language	3-0-3	3-0-3	6-0-6
Electives[4] Free	....	....	3-0-3
Electives[5] Physical Education	X-X-2	X-X-1	X-X-1
Totals	X-X-18	X-X-17	X-X-20

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
AE 2101 Introduction to Aircraft Structures	....	....	4-0-4
AE 2603[6] Digital Computers	....	....	1-6-3
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	3-0-3	....
MATH 2307[2] Calculus IV	5-0-5	....	....
MATH 2308[2] Calculus and Linear Algebra	....	5-0-5	....
MATH 2309[2] Ordinary Differential Equations	....	....	5-0-5
ME 3322 Thermodynamics	....	....	3-0-3
PHYS 2122-3[2] Physics	4-3-5	4-3-5	....

Course	1st Q.	2nd Q.	3rd Q.
Electives[3] Humanities/Social Science/ Modern Language	3-0-3	3-0-3	....
Electives[4]	....	....	3-0-3
Totals	15-3-16	15-3-16	16-6-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
AE 3000-1-2 Fluid Mechanics I, II, III	4-3-5	4-3-5	4-3-5
AE 3103 Fundamentals of Stress Analysis	3-0-3	....	....
AE 3104 Energy Methods and Stability of Structures	....	3-0-3	....
AE 3110 Structures Lab	1-3-2	....	....
EE 3700 Circuits and Instruments	3-0-3	....	....
EE 3710 Electronic Systems	....	3-0-3	....
ESM 4210 Mechanical Vibrations	....	....	3-0-3
ENGL 3023 Written Communication in Science, Business, and Industry	....	3-0-3	....
MATH 4582 Advanced Engineering Math	....	....	3-0-3
Electives[3] Humanities/Social Science/ Modern Language	3-0-3	6-0-6	6-0-6
Totals	14-6-16	19-3-20	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
AE 4000 Fluid Mechanics IV	4-3-5	....	....
AE 4101 Analysis of Thin-walled Structural Elements	3-0-3	....	....
AE 4102 Selected Topics in the Analysis of Aircraft Structures	....	....	3-0-3
AE 4110 Structures Lab	1-3-2	....	....
AE 4200 Vibration and Flutter	....	....	3-0-3
AE 4250 Jet Propulsion	....	5-0-5	....
AE 4350-1 Aerospace Engineering Design Project I, II	....	2-6-4	2-6-4
AE 4410 Vehicle Performance	3-0-3	....	....
AE 4500 Stability and Control	....	5-0-5	....
Electives[3] Humanities/Social Science/ Modern Language	....	....	3-0-3
Electives[7] Free	3-0-3	3-0-3	3-0-3
Totals	14-6-16	15-6-17	14-6-16

[1]See College of Engineering section in "Curricula and Courses of Instruction" for engineering electives. EE 1010 cannot be used.
[2]A "C" grade or better is required in each Math and Physics course.
[3]Eighteen credit hours in humanities and eighteen credit hours in social science are required for graduation. To satisfy these requirements, humanities and social science courses must be selected from the College of Engineering listings in "Information for Undergraduate Students." Courses taken in humanities and social sciences must be scheduled as letter grade courses. ENGL 1001, 1002 plus three credit hours of English literature are required.
[4]These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.
[5]See "Curricula and Courses of Instruction." Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Ceramic Engineering

Established in 1924

Director—Joseph L. Pentecost; *Professors,* James F. Benzel, A. T. Chapman, Willis E, Moody; *Associate Professor*—Joe K. Cochran, Jr., *Research Engineer and Lecturer* --David N. Hill; *Special Lecturer*—R. A. Young.

General Information

The ceramic industry produces over $20 billion worth of products annually in the United States. These products range from brick, tile, glass, portland cement, and dinnerware to high-temperature refractories for furnace linings, abrasives, and sophisticated electronic components. These traditional products create a continuing demand for personnel trained in this field and new products which are continuously developing open new opportunities. Over the past twenty years these new products have included rocket nozzles and jet engine components, electronic circuitry for computers, and fiberglass products for nose cones and missiles. Current developments include automotive exhaust catalyst supports and other pollution control devices, new lighting techniques, and electrooptical materials.

The raw materials for ceramic products are the most plentiful minerals in the earth's crust. Consequently, many are relatively cheap and result in durable, economical, temperature-resistant materials that are in continuous demand for innovative design.

Ceramic engineering applies sound scientific and engineering principles to solve manufacturing problems in the industry. Frequently these problems are complex and challenging for chemical and physical reactions are occurring at high temperatures. Measurements are difficult and cost constraints for economical production are always present.

The School of Ceramic Engineering offers a four-year curriculum leading to the bachelor's degree and graduate work leading to Master of Science and Doctor of Philosophy degrees in ceramic engineering. The undergraduate curriculum is designed to prepare the degree candidate for a position in the ceramic industry or for graduate work. Courses are also offered to nonmajors to introduce them to ceramic materials and processes or to develop specific skills and knowledge in the application of ceramic materials.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1111-2 General Chemistry	4-3-5	4-3-5	....
CHEM 2113 Chemical Principles	....	....	3-3-4
ELECTIVE EGR 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives[1]	X-X-3	X-X-3	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives[3] Physical Education	0-4-1	0-4-1	2-2-2
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2] Free	....	....	3-0-3
Totals	14-10-17	14-10-17	16-5-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CERE 3101 Ceramic Data Handling	....	....	3-3-4
CERE 3002 Properties of Engineering Materials	....	....	2-3-3
ESM 2201 Statics	....	3-0-3	....
ESM 3301 Mechanics of Deformable Bodies	....	....	5-0-5
GEOS 2100 General Geology	3-0-3	....	....
GEOS 2102 General Geology Laboratory	0-3-1	....	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	....
Electives[2] Free	....	3-0-3	....
Totals	15-6-17	18-3-19	14-9-17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CERE 3003 Ceramic Processing I	3-3-4	....	....
CERE 3004 Ceramic Processing II	....	2-3-3	....
CERE 3105 Phase Equilibria for Ceramists	3-0-3	....	....
CERE 3006 Physical Ceramics I	3-0-3	....	....
CERE 3007 High Temperature Analysis	....	2-3-3	....
CERE 3008 Glass Technology I	....	2-3-3	....
CERE 4018 Drying and Psychrometry	....	....	2-0-2
CERE 4042 Seminar	....	1-0-1	....
CERE 4052 Inorganic Phase Analysis and Identification	....	....	3-3-4
CHEM 3412-3 Physical Chemistry	....	3-0-3	3-0-3
CHEM 3481 Physical Chemistry Laboratory	....	....	0-6-2
ME 3720 Thermodynamics	4-0-4	....	....
ME 3342 Transport Phenomena I or			
ME 4714 Heat Transfer	....	....	3-0-3
ESM 3201 Dynamics I or			
ESM 3302 Mechanics of Materials	3-0-3	....	....
Electives Humanities/Social Science/Modern Language	....	6-0-6	3-0-3
Totals	16-3-17	16-9-19	17-9-17

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CERE 4102 Refractories	3-3-4	....	....
CERE 4003 Physical Ceramics II	....	2-3-3	....
CERE 4004 High Temperature Thermodynamics	....	....	2-0-2
CERE 4005 Glass Technology II	2-3-3	....	....
CERE 4110 Energy Conversion & Control	....	2-3-3	....
CERE 4115-6-7 Independent Research Project I, II, III	1-0-1	0-3-1	0-6-2
CERE 4043 Seminar	....	1-0-1	....
ISYE 4725 Engineering Economy	3-0-3	....	....
Elective Either EE 3700, Elements of Electrical Circuits and Instruments (3-0-3) or EE 3725, Electric Circuits and Fields (2-3-3)	X-X-3	....	....
Elective Metallurgy	....	3-0-3	....
Elective Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Elective Free	....	3-0-3	6-0-6
Totals	15-6-17	14-9-17	14-6-16

[1]See College of Engineering section "Curricula and Degrees" for engineering electives.
[2]These free elective courses may be taken at any time during a student's course of study.
[3]See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Chemical Engineering

Established in 1901
Director and Professor—Gary Poehlein; *Chemical Engineering Faculty—Professors* —Charles W. Gorton, Michael J. Matteson, John D. Muzzy, Robert J. Samuels, A. H. Peter Skelland, Jude T. Sommerfeld, Henderson C. Ward, Jack Winnick; *Associate Professors*—Larry J. Forney, William R. Ernst, Amyn Teja; *Assistant Professors*—Pradeep K. Agrawal, Allan S. Myerson, Ronnie S. Roberts, D. William Tedder, Mark G. White, Ajit P. Yoganathan, F. Joseph Schork; *Adjunct Professors*—George A. Fowles, Charles Aloisio, Jr.; *Metallurgy Faculty: Professors*—Robert F. Hochman; Helen Grenga, John Husted, Ervin E. Underwood; *Associate Professors*—Miroslav Marek, Pieter Muije. *Fracture & Fatique Research Laboratory—Professor and Director*—Edgar A. Starke, Jr.; *Research Scientists*—Fu-Shiong Lin, Koji Yamaguchi; *Post Doctorals*—Rong-Tsang Chen, Kumar Jatavallabula.

Chemical Engineering Program

General Information

Chemical engineers perform essential functions in industries that convert raw materials into useful finished products by means of chemical and physical processes. Almost every major manufacturing industry employs chemical engineers in research, development, design, production, sales, consulting, and management positions. Substantial numbers of chemical engineers are employed in petroleum, petrochemical, pulp and paper, plastics, metallurgical, fiber, fertilizer, nuclear energy, space, rubber, food, photographic, heavy and fine chemical, mineral, pharmaceutical, textile, and dye industries. Energy problems and environmental and pollution control activities require an increasing number of chemical engineers.

The School of Chemical Engineering offers programs leading to the degrees Bachelor of Chemical Engineering, Master of Science in Chemical Engineering, Master of Science in Metallurgy, and Doctor of Philosophy. The doctoral program may be in either chemical engineering or metallurgy. Interdisciplinary programs and undesignated degrees are also available.

The following curriculum leads to the degree of Bachelor of Chemical Engineering and is designed to train students both for positions immediately upon graduation or for additional study leading to the master's and doctoral degrees.

It is a requirement of the School of Chemical Engineering that every required chemical engineering course be passed with a grade of C or better.

A six-week summer study program in the Department of Chemical Engineering of the University College London in London, England was initiated in the summer quarter, 1975. Selected juniors who participated in this program are allowed twelve credit hours of free or technical electives, some of which may be substituted for selected chemical engineering laboratory courses.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHE 1101 Introduction to Chemical Engineering	1-0-1	....	....
CHEM[1] 1111-2 General Chemistry	4-3-5	4-3-5	....
CHEM 2113 Chemical Principles	....	....	3-3-4
ENGL[2] 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
MATH 1307-8-9 Calculus	5-0-5	5-0-5	5-0-5
Elective[3] Freshman Engineering Elective	....	X-X-3	....
Electives[4] Freshman Physical Education	X-X-2	X-X-1	X-X-1
Electives[5]	3-0-3	....	6-0-6
Totals	X-X-19	X-X-17	X-X-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 2207-8 Chemical Process Principles	3-0-3	3-0-3	....
CHE 2209 Computers in Chemical Engineering	....	....	2-3-3
CHE 3300 Transport Phenomena	....	....	3-0-3
MATH 2307-8 Calculus	5-0-5	5-0-5	....
PHYS 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381 Organic Chemistry Laboratory	....	0-6-2	....
Electives	....	....	3-0-3
Totals	15-3-16	15-9-18	15-6-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 3301 Transport Phenomena	3-0-3	....	....
CHE 3302-3 Transport Phenomena Laboratory	0-3-1	0-3-1	....
CHE 3306-7 Unit Operations	....	3-0-3	3-0-3
CHEM 3411-2-3 Physical Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3481 Physical Chemistry Laboratory	....	....	0-6-2
ESM 2201 Statics	3-0-3	....	....
EE 3700 Electrical Circuits and Fields	....	....	3-0-3
EE 3740 Electrical Engineering Laboratory	....	....	0-3-1
MET 3301 Engineering Materials	....	4-3-5	....
Electives	6-0-6	6-0-6	6-0-6
Totals	15-3-16	16-6-18	15-9-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
CHE 4438 Chemical Engineering Thermodynamics	4-0-4	....	....
CHE 4415 Reactor Design	....	3-0-3	....
CHE 3308 Unit Operations	3-0-3	....	....
CHE 3309-10 Unit Operations Laboratory I, II	0-3-1	0-3-1	....
ICS 2250 Technical Information Resources	1-0-1	....	....
CHE 4431 Chemical Engineering Economics	3-0-3	....	....
CHE 4432 Process and Equipment Design	....	2-3-3	....
CHE 4434 Plant Design	....	....	1-6-3
CHE 4416 Process Control	....	3-3-4	....
Electives	6-0-6	6-0-6	12-0-12
Totals	17-3-18	14-9-17	13-6-15

Multidisciplinary Programs
See table on page 80.

[1]CHEM 1111-2, advanced level chemistry, is required for all chemical engineering majors. Students transferring into chemical engineering from other curricula not requiring the advanced level chemistry will be allowed to substitute CHEM 1101-2 for CHEM 1111-2, respectively, if taken prior to transferring
[2]ENGL 1001-2-3 is required for all chemical engineering majors and satisfies nine hours of the humanities requirement. Students transferring into chemical engineering from other curricula not requiring ENGL 1001-2-3 or students granted advanced placement will be allowed to substi-

School of Civil Engineering

Established in 1896

Director—J. Edmund Fitzgerald; *Assistant Director*—Paul H. Sanders; *Regents' Professors*—Satya N. Atluri, Paul G. Mayer, George F. Sowers; *Professors*—Richard D. Barksdale, Austin B. Caseman, Edward S. K. Chian, Donald O. Covault, Leroy Z. Emkin, Daniel W. Halpin, James S. Lai, Charles S. Martin, Frederick G. Pohland, Quentin L. Robnett, William M. Sangster, Thomas E. Stelson, Earl M. Wheby, Paul H. Wright; *Associate Professors*—Mustafa M. Aral, Larry J. Forney, Barry J. Goodno, Lawrence F. Kahn, Boris M. Khudenko, Billy B. Mazanti, Paily P. Paily, Peter S. Parsonson, F. Michael Saunders, Calvin W. Tooles, I. Edwin Wilks, Kenneth M. Will; *Assistant Professors*—Joseph P. Gould, Achintya Haldar, Edward R. Johnson, Byung R. Kim, Sai Hyun Lee, Srinivasa R. G. Rao, Philip J. W. Roberts, Terry W. Sturm; *Instructors*—Robert C. Bachus, Larry W. Hess, Hyman A. Todres; *Adjunct Professor*—Patrick M. Quinlan.

General Information

The School of Civil Engineering offers courses in civil engineering and engineering graphics and programs leading to the degrees Bachelor of Civil Engineering, Bachelor of Science (undesignated), Master of Science in Civil Engineering, Master of Science in Environmental Engineering, Master of Science (undesignated), and Doctor of Philosophy. Also offered is a joint two-year program leading to the awarding of the degrees Master of Science in Civil Engineering or Master of Science (undesignated, major in transportation engineering), and Master of City Planning.

Multidisciplinary Programs

See table on page 80.

Program in Engineering Graphics

The School of Civil Engineering offers EGR 1170, Introduction to Visual Communication and Engineering Design. This course is required in many engineering curricula and acceptable as an elective in the other engineering curricula and in many non-engineering curricula.

The objective of the course is to teach the student the principles of graphic expression. It is recommended that this course be scheduled during the freshman year, so that principles learned therein may be used in later engineering courses.

Bachelor of Civil Engineering

The four-year curriculum leading to the degree Bachelor of Civil Engineering is designed to enable the graduate to enter professional practice as an engineer or to continue his or her studies in programs leading to advanced degrees in the following broad fields of specialization: construction, environmental engineering, fluid mechanics, hydraulics, hydrology, materials, environmental engineering, soil mechanics, structures, surveying, transportation and water resources planning and management. The graduate of the B.C.E. curriculum may function in the areas of planning and design, construction, research and development, operations, and maintenance. The curriculum leading to the degree Bachelor of Civil Engineering has been continuously accredited by the Accreditation Board for Engineering and Technology since the inauguration of its accrediting program during the period 1936-38. Graduates of the B.C.E. curriculum are eligible to seek licensing as registered professional engineers.

The course requirements of the Bachelor of Civil Engineering degree are tabulated here. Many of the courses need not be taken during the quarter indicated, but prerequisites must be satisfied.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the following are also required for the B.C.E. degree.

(a) The scholastic average shall be a minimum of 2.0 for those quarters during which the last fifty-four hours toward the degree are taken.

(b) The number of quality points earned in civil engineering courses taken toward the degree must be at least twice the number of credit hours in those courses.

(c) No more than twelve hours of free electives may be taken on a pass/fail basis. No other courses may be taken on a pass/fail basis.

Students who complete both the bachelor's and master's degrees in the School of Civil Engineering may use up to nine credit hours of graduate level course work (as approved by the C.E. School) in the major discipline for both degrees. In order to qualify for this option the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the Master's degree within a two-year period from the award date of the bachelor's degree.

Freshman Year

Courses	1st Q.	2nd Q.	3rd Q.
CHEM 1101 Inorganic Chemistry	4-3-5	....	....
BIOL 1720 Biological Principles	....	4-3-5	....
PHYS 2121 Physics	....	....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communications	2-3-3	....	....
CE 1503[1] Freshman Engineering Elective	....	2-3-3	....
ECON 2000 Economics	....	....	3-0-3
ENGL 1001-2 Introduction to Literature	3-0-3	3-0-3	....
Electives[6] Humanities/Social Science/Modern Language	....	....	3-0-3
Electives[2] Free	1-0-1	1-0-1	....
Electives[3] Physical Education	X-X-1	X-X-1	X-X-2
Totals	X-X-18	X-X-18	X-X-18

Sophomore Year

Courses	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Physics	4-3-5	....	....
Elective[7] Either PHYS 2123, Physics, or CHEM 1102, Inorganic Chemistry	....	4-3-5	....
CE 2264 Surveying	....	....	3-3-4
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
MATH 3709 Mathematics for Systems Engrg.	....	....	3-0-3
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics	....	3-0-3	....
ESM 3301 Mechanics of Deformable Bodies	....	....	5-0-5
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2] Free	1-0-1	1-0-1	1-0-1
Totals	16-3-17	16-3-17	15-3-16

Junior Year

Courses	1st Q.	2nd Q.	3rd Q.
CE 3513 Digital Computers	3-0-3	....	....
CE 3224 Structural Analysis	3-3-4	....	....
CE 3534 Stochastic Methods	3-3-4	....	....
GEOS 2100 Physical Geology	3-0-3	....	....
GEOS 2102 Physical Geology Laboratory	0-3-1	....	....
Elective[7] Either ME 3720, Thermodynamics or CHEM 2113, Chemical Principles	X-X-4	....	....
CE 4108-18 Environmental Engineering I, II	....	3-0-3	3-0-3
CE 3309 Materials of Construction	....	3-3-4	....
CE 3053-4 Fluid Mechanics I, II	....	3-0-3	3-3-4
ENGL 3023 Technical Writing	....	3-0-3	....
Elective[4] Free	....	3-0-3	....
CE 4204 Metal Structural Components	....	....	3-3-4
CE 4154 Behavior of Soil and Rock	....	....	3-3-4
EE 3700[8] Elements of Electrical Circuits and Instruments	....	....	3-0-3
EE 3740[8] Electrical Instrumentation Laboratory	....	....	0-3-1
Totals	X-X-19	15-3-16	15-12-19

Senior Year

Courses	*1st Q.*	*2nd Q.*	*3rd Q.*
CE 4214 Concrete Structural Components	3-3-4	....	....
CE 4163 Soil and Rock Engineering	2-3-3	....	....
CE 3061 Fluid Mechanics Laboratory	0-3-1	....	....
Electives[5] CE	3-0-3	3-0-3	3-0-3
CE 4353 Hydrology	3-0-3	....	....
Electives[6] Humanities/Social Science/Modern Language	3-0-3	6-0-6	6-0-6
CE 4304 Transportation Engineering I	....	3-3-4	....
ISYE 4725 Engineering Economy	....	3-0-3	....
CE 4003 Construction	....	....	2-3-3
Elective[4] Free	....	....	3-0-3
Totals	14-9-17	15-3-16	14-3-15

[1]See College of Engineering section "Curricula and Courses of Instruction" for engineering electives which can be substituted for CE 1503.
[2]These free elective courses may be taken at any time during a student's course at study. Physical education courses may not be used to satisfy this requirement.
[3]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for physical education requirements.
[4]Six hours of free electives at the 3000 level or higher, except Physical Education, must be taken if advanced ROTC is not taken.
[5]CE Electives. Nine hours chosen from 4000-level CE courses, not otherwise required in the BCE curriculum, or graduate level CE courses as approved by advisor and director (minimum of 2.7 average required for an undergraduate to take a graduate course).
[6]See "Information for Undergraduate Students" section of this catalog for humanities, social science, and modern language requirements.
[7]CHEM 1102 is prerequisite for CHEM 2113, recommended for specialization in Environmental Engineering. PHYS 2123 is corequisite for ME 3720.
[8]EE 3700 is corequisite for EE 3740, but the reverse is not true.

School of Electrical Engineering

Established in 1896

Director and Professor—Demetrius T. Paris; *Associate Director and Professor*—Roger P. Webb (Georgia Power Chair); *Assistant Director for Graduate Affairs and Professor*—Dale C. Ray; *Assistant Director for Undergraduate Affairs and Professor*—Thomas M. White, Jr.; *Regents' Professors*—John W. Hooper, George P. Rodrigue, Ronald W. Schafer (John O. McCarty/Audichron Chair), Kendall L. Su; *Professors*—Cecil O. Alford, Henry C. Bourne, Aubrey M. Bush, J. Alvin Connelly, Atif S. Debs, Robert K. Feeney, Daniel C. Fielder, Thomas K. Gaylord, Joseph L. Hammond, Jr., Edward B. Joy, Edward W. Kamen, John D. Norgard, John B. Peatman, Joseph M. Pettit, William T, Rhodes, Jay H. Schlag, Albert P. Sheppard, Jr., Charles R. Vail; *Associate Professors*—Thomas P. Barnwell III, William R. Callen, Jr., John C. Field (visiting), G. Keith Huddleston, W. Marshall Leach, Jr., Russell M. Mersereau, Mohamed F. Moad, Hans B. Puttgen, William E. Sayle II, Glenn S. Smith, John M. Wallace, Jr.; *Assistant Professors*—Chee-Yee Chong, Mark A. Clements, Kent R. Davey, John F. Dorsey, Monson H. Hayes, Donald J. Healy, David R. Hertling, Frank L. Lewis, Stephen R. McConnel (visiting), Athan P. Meliopoulos, Mohamed G. Moharam, John P. Uyemura, Erik I. Verriest; *Instructor*—Thomas E. Brewer; *Lecturers*—William T. Anderson, Allen H. Cherin, Clayton H. Griffin, Robert D. Hayes, Christopher J. M. Hodges, Terence E. Keene, Terrence A. Lenahan, Jay T. Loadholt III, M. David Prince.

General Information

Electrical engineers have pioneered the fields of electronics, computers, control, power, and communication. Their work is vital in almost every sector of society. The tremendous effect of electrical engineering on society can be explained by the fact that electrical energy is the only known form of energy which can be transmitted efficiently under controlled conditions, even through a vacuum, and by means of which intelligence can be processed and transferred effectively even over extremely long distances.

The School of Electrical Engineering seeks to attract students who possess a verbal and written command of the English language, who exhibit logical thinking, creativity, curiosity, imagination, persistence, patience, and who have proved their academic excellence in mathematics, chemistry, and physics.

At the undergraduate level, the basic required program of instruction in fundamental theory and laboratory practice is balanced by a broad range of electives. These electives are available in a wide variety of major areas such as audio engineering, communications, computer engineering, energy engineering, instrumentation, controls, and optical engineering. The student, with the counsel and guidance of faculty advisors, designs his or her electives program around his or her own special interests.

The graduate programs leading to the master's and doctoral degrees are designed to provide a broad education covering more than one specialty, followed by in-depth studies of major and minor interest areas. The doctoral program requires, in addition, concentration in a single specialty or in a group of closely related specialties.

Graduate programs include communications, computer systems, control systems, electric power, optical engineering, electromagnetics, instrumentation, network and system theory, physical electronics, and signal processing. Multidisciplinary programs in areas such as computer engineering and acoustic engineering are offered jointly with other engineering schools on campus. Full programs of courses are offered during the summer quarter, making it possible for part-time students to continue an uninterrupted program of study throughout the year.

Housed in one of the finest facilities in the world, the school maintains a vigorous program of student-centered research conducted in well-equipped laboratories.

Additional information about the programs may be obtained from the school's *Student Handbook*, available upon request, or by calling the school at (404)894-2900. This source of information must be consulted with respect to special rules and degree requirements by every student enrolled.

Certificate Program in Computer Engineering

Computers have become an integral part of today's society and are now used in all facets of society including scientific research, industry, business, commerce, and now even the home with calculators and computer controlled appliances. With this increasing use comes an increasing demand for people who understand the design, construction, operation, and application of computers. To satisfy this demand, new programs in computer engineering have been developed.

Computer engineering in the School of Electrical Engineering encompasses both traditional areas of computer engineering—the engineering *of* computers and engineering *with* computers. Engineering *of* computers emphasizes the design of computers and requires expertise in computational theory, digital design, and computer architecture. Engineering *with* computers emphasizes the use of computers in engineering systems and requires computer interfacing techniques, both low level and high level programming techniques, and a general knowledge of computer operating systems. Both areas require an in-depth understanding of computer software at the elementary and systems level. Hence, computer engineering encompasses all aspects of design, theory, and practice relating to: systems for digital and analog computation and information processing; components and circuits for computing systems; relevant portions of supporting disciplines; production, testing, operation, and reliability of computing systems; applications, use, and programming of computing devices and information processing systems; and the use of computers in electrical and electronic engineering.

Those undergraduate engineering students who specialize in the area of Computer Engineering will be awarded a Certificate in Computer Engineering. To qualify for this certificate, a student must complete all requirements for an ABET-accredited bachelor's degree in an engineering discipline and, in addition, must successfully complete, with a grade of C or better, the following nine elective courses, totaling thirty quarter hours: EE 1010, EE 3032, EE 3033, EE 3034, EE 4075, EE 4077, EE 4080, ICS 2100, and MATH 2020. None of these courses are to be required by title and number for the bachelor's degree in the student's major field. Non-electrical engineering students may substitute EE 3360 for one of the EE courses listed in the program.

Further details may be obtained by directly contacting the School of Electrical Engineering.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Electives[1]	....	3-0-3	3-0-3
Electives[2] Humanities/ Social Science/ Modern Language	....	....	3-0-3
ENGL 1001-2	3-0-3	3-0-3	....
Elective Any one of the freshman engineering electives[5]	X-X-3	....	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	....	....	4-3-5
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
Electives[3] Physical Education	X-X-2	X-X-1	X-X-1
Totals	X-X-18	X-X-17	X-X-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Electives[1]	3-0-3	....	....
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	....	3-0-3
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus V	....	5-0-5	....
MATH 3308 Differential Equations	....	....	5-0-5
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
EE[4] 3200-50 Elements of Electrical Engineering	....	3-0-3	3-0-3
EE 3400 Instrumentation Laboratory	....	....	1-3-2
Totals	18-3-19	15-3-16	15-3-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Electives[1]	1-0-1	4-0-4	4-0-4
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
EE 3300-10-20 Electromagnetics	3-0-3	3-0-3	3-0-3
EE 3210-20 Circuits and Systems	3-0-3	3-0-3	....
EE 3215 Signals and Systems	....	....	3-0-3
EE 3260 Engineering Electronics	3-0-3	....	....
EE 3270 Nonlinear Devices and Circuits	....	3-0-3	....
EE 3330 Electromechanical Systems and Energy Conversion	....	....	3-0-3
EE 3360 Digital Hardware	3-0-3	....	....
EE 3411-21-31 Junior EE Laboratory I, II, III	0-3-1	0-3-1	0-3-1
Totals	16-3-17	16-3-17	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Electives[1]	10-0-10	13-0-13	13-0-13
Electives[2] Humanities/ Social Science/Modern Language	3-0-3	3-0-3	3-0-3
EE 4350 Materials Science	3-0-3	....	....
EE 4411-21 Senior EE Laboratory I, II	0-3-1	0-3-1	....
EE 4430 Project Laboratory	....	....	0-3-1
Totals	16-3-17	16-3-17	16-3-17

[1]Electives: The electrical engineering curriculum contains fifty-seven hours of electives, in addition to four hours of specified physical education electives and thirty hours of specified humanities/social science/modern language electives. The fifty-seven hours of electives must include a minimum of:

Three hours of freshman engineering electives. See "Curricula and Courses of Instruction," College of Engineering.

Three hours of junior-level or senior-level course work in written or verbal communications of ideas which may be one of the following English courses: ENGL 3015, ENGL 3023, ENGL 3024.

Twelve hours of technical electives subject to school approval. Generally, the technical electives are junior or senior engineering (not EE), mathematics, or natural science courses. These electives must include one of the following five thermodynamics options: (1) ME 3720 (2) ME 3726 (3) ME 3322 and ME 3323 (4) PHYS 3141 or (5) a course or courses approved by the School of Electrical Engineering. In addition, one course in graphics is strongly recommended.

Eighteen hours of electrical engineering electives, subject to school approval.

Three hours (minimum) of applied probability selected from: (1) EE 3340 (2) PHYS 3145 (3) ISYE 3027 (4) BIOL 3333 (5) MATH 3710 (6) MATH 3215 or (7) MATH 4215. EE 3340 will apply toward satisfying the EE elective course requirements; all other courses will apply toward satisfying the technical breadth requirement for the bachelor's degree in electrical engineering.

Twenty-one hours of free electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit in the program.

[2]Three credit hours each of history and political science must be included. Additional humanities/social science/ modern language electives and their required distribution are given in "Information for Undergraduate Students," Academ-

School of Engineering Science and Mechanics

Established in 1959

Director and Professor—Milton E. Raville; *Associate Director and Professor*—Wilton W. King; *Regents' Professor*—Andrew W. Marris; *Professors*—William J. Lnenicka, David J. McGill, George M. Rentzepis, George J. Simitses, Charles E. S. Ueng, James T. S. Wang, Gerald A. Wempner; *Associate Professors*—Jerry M. Anderson, Donald G. Berghaus, Michael C. Bernard, Hyland Y. L. Chen, John C. Clark, Robert W. Shreeves, Raymond P. Vito, Wan-Lee Yin; *Assistant Professors*—William A. Johnston, Arthur J. Koblasz, Richard K. Kunz, John G. Papastavridis, Donald L. Vawter.

General Information

The School of Engineering Science and Mechanics administers the undergraduate curriculum leading to the degree of Bachelor of Engineering Science and Mechanics and graduate programs leading to the degrees of Master of Science, Master of Science in Engineering Science and Mechanics, and Doctor of Philosophy.

The primary objective of the undergraduate curriculum is to prepare students for careers in engineering and related fields emphasizing the fundamental principles and techniques of mathematics and the engineering sciences—solid mechanics, fluid mechanics, materials science, electrical sciences, heat transfer, and thermodynamics. The curriculum, totaling 206 credit hours, provides for 83 hours of electives, 30 hours of technical electives, 33 hours of humanities/social science/modern language electives, and 4 hours of physical education electives. The engineering science and mechanics curriculum is considered particularly well-suited for the above average student whose specific goals within the general framework of engineering and the physical sciences have not yet been formulated.

Elective options provide in-depth study in interdisciplinary, technically-related areas as well as preparation for professional schools of business, law, and medicine. Thus, the engineering science and mechanics graduate has a wide choice of specialized areas that can provide a foundation for starting his or her career or for further study.

The faculty members of the School of Engineering Science and Mechanics hold degrees in most of the recognized branches of engineering, as well as mathematics and physics. Housed in two buildings, ESM has excellent classroom, office and shop facilities, and modern, newly-equipped laboratories. Various grants, assistantships, and fellowships are available to students of outstanding merit.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
Elective[1] Engineering	X-X-3	....	....
CHEM 1101-2 Inorganic Chemistry	4-3-5	4-3-5	....
EGR 1170 Visual Communication Engineering Design I	....	2-3-3	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Physics	....	....	4-3-5
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2] Free	....	....	3-0-3
Elective[6] Physical Education	X-X-2	X-X-1	X-X-1
Totals	X-X-18	X-X-17	X-X-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 2101-2 Engineering Design I, II	0-3-1	0-6-2	....
ESM 2201 Statics	3-0-3	....	....
ESM 3201-2 Dynamics I, II	....	3-0-3	3-0-3
EE 3200 Elements of Electrical Engineering	....	....	3-0-3
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 or 3308 Differential Equations	....	....	5-0-5

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122-3 Physics	4-3-5	4-3-5	....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective[2] Free	....	....	3-0-3
Totals	15-6-17	15-9-18	17-0-17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 3111 Experimental Methods in Engr. Science	....	....	2-3-3
ESM 3301 Mechanics of Deformable Bodies	5-0-5	....	....
ESM 3302 Mechanics of Materials	....	3-0-3	....
ESM 3501 Fluids Mechanics	....	....	5-0-5
ESM 4210 Mechanical Vibrations	....	....	3-0-3
EE 3250 Elements of Electrical Engineering	3-0-3	....	....
EE 3400 Instrumentation Laboratory	....	1-3-2	....
ENGL 3023 Written Communication in Science, Business, and Industry	3-0-3	....	....
ME 3322 Thermodynamics	3-0-3	....	....
ME 3323 Thermodynamics	....	3-0-3	....
ME 3342 Transport Phenomena I	....	....	3-0-3
Elective[3] Mathematics	....	3-0-3	....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	....
Electives Free	....	3-0-3	3-0-3
Totals	17-0-17	16-3-17	16-3-17

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 3451 Computer Applications in Engineering Science& Mechanics	3-0-3	....	....
ESM 4122-3 Projects in Engineering Science	0-3-1	0-6-2	....
ECON 2000 Survey of Principles of Economics	3-0-3	....	....
MET 3301 Engineering Materials	4-3-5	....	....
Elective Either ISYE 4000, Introduction to Systems Theory, or ME 4445, Automatic Control	....	....	3-0-3
Elective[3] Mathematics	....	3-0-3	....
Elective[4] Physics	....	3-0-3	....
Electives Technical	3-0-3	6-0-6	6-0-6
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives* Free	....	....	4-0-4
Totals	16-6-18	15-6-17	16-0-16

*At east six hours of electives must be in the area of design, synthesis, or systems.

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[1]See College of Engineering section, "Curricula and Courses of Instruction" for engineering electives.

[2]These free elective hours may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then it should be scheduled beginning at the first quarter the student is enrolled. A maximum of nine hours of free electives in junior and senior years may be in advanced ROTC.

[3]To be selected from MATH 3110, 4215, 4320, 4581, 4582.

[4]To be selected from PHYS 3138, 3143, or 3751. If PHYS 3138 or 3143 is chosen, the extra two credits will be used as technical electives.

[5]At least six hours of electives must be in the area of design, synthesis, or systems.

[6]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Health Systems

Established in 1977, program in 1972, option in 1958

Director and Regents' Professor—Harold E. Smalley; *Professor*—James B. Mathews (adjunct); *Associate Professors*—Richard M. Bramblett (adjunct), Justin A. Myrick, Nathaniel Pugh, Jr.; *Assistant Professor*—Thomas H. Bowlin; *Lecturers*—Howard E. Fagin, Julian V. Pittman, Nelson F. Sayford, Milton E. F. Schoeman, Charles Y. Thomason, III; *Research Associate II*—Ann A. Bailey.

General Information

Health Systems is that field of study and practice aimed toward improving the delivery of health care services through the application of systems science and management engineering. Emphasis is upon systematic planning, engineering design, and scientific management in respect to health care facilities, manpower, and methods. Because of the complexity of health care management problems, the body of knowledge that has come to be known as health systems builds upon and draws from other branches of engineering, computer technology, management science, architecture, behavioral science, and the various health professions. Health systems is an allied health field grounded in the engineering profession.

A career in this field is challenging and rewarding in many ways. Health care is humanitarian and health services are important to society; the industry is large, expensive, and in need of improvement. A career in health systems is an opportunity to use modern scientific methods in the performance of a vital public service.

Health systems specialists are in short supply and there are many job openings with hospitals, nursing homes, doctors' offices, government agencies, universities, medical centers, research and planning organizations, manufacturers of hospital equipment, health insurance companies, management consultants, architectural firms, and construction contractors.

The School of Health Systems is an academic division of Georgia Tech's College of Engineering and it is affiliated with the Medical College of Georgia. The school has extensive programs of education, research and service, and through the Health Systems Research Center, it engages in interdisciplinary and interinstitutional research, continuing education, and community outreach activities.

Programs of the school are a direct outgrowth of faculty involvement in this field since 1952 and of a health-related academic program begun at Georgia Tech in 1958. The school has been admitted to institutional membership in the Georgia Hospital Association and the American Hospital Association, the American Society of Allied Health Professions, the American Health Planning Association, and the Association of University Programs in Health Administration. Close working relationships are also maintained with the Hospital Management Systems Society and with the Health Services Division of the American Institute of Industrial Engineers.

B.S.H.S. Curriculum

The undergraduate program was designed to prepare students for professional careers in the field of health systems, and it provides an academically sound base for lifelong learning. Even though it is technical and analytical, the program of study places some emphasis upon interpersonal, organizational, and societal relationships. Although it is directed toward the health field, the program provides students with valuable knowledge and marketable skills needed in many different fields.

The curriculum enables students to keep their options open for a variety of positions in the health field. It provides considerable flexibility so that students from various fields can transfer into it without losing credit already earned. It contains sufficient electives to accommodate several specialty interests, including health systems analysis, health systems planning, and premedical preparation. Modified versions of this curriculum are available under the dual degree (3—2) program.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 11 01-2 General Chemistry	....	5	5
EGR 1170 Engineering Graphics	3	....	....
ENGL 1001-2[1] Analysis of Literature	3	3	....
HS 1000 Overview of Health Systems	1	....	....
MATH 1307-8-9 Calculus I, II, III	5	5	5
POL 1251[2] Government of the US[3]	....	3	....

Elective English/Humanity[4]	....	....	3
Elective: HIST 1001 or 2[2] History of the U.S.[3]	3	....	....
Electives[5] Physical Education	2	1	1
Elective[2] Social Science	....	....	3
Totals	17	17	17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ECON 2000-1[2] Economic Principles	3	3	....
HS 2011 The Health Field	....	....	3
ICS 1700 Computer Programming	....	3	....
ISYE 3027 Applications of Probability	....	3	....
ISYE 3028 Engineering Statistice I	....	....	3
MGT 2000 Accounting I	....	....	3
MATH 2307 Calculus IV	5	....	....
PHYS 2121-2-3 Engineering Physics	5	5	5
Electives[4] Humanities	3	3	3
Elective[6] Free	3	....	....
Totals	19	17	17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ENGL 3023 Written Communications	....	3	....
HS 3011 Hospital Functions	3	....	....
HS 3021 Nonhospital Components	....	3	....
HS 3115-6 Management Engineering I, II	4	3	....
HS 3117-8 Management Engineering III, IV	....	3	3
HS 3211 Data Processing	....	....	3
HS 3351 Projects and Reports	....	....	3
ISYE 3025 Engineering Economy	....	....	3
ISYE 3029 Engineering Statistics II	3	....	....
ISYE 3131 Operations Research	....	....	3
MGT 2001 Accounting II	3	....	....
MGT 3060 Finance	....	3	....
Elective[6] Free	3	3	3
Totals	16	18	18

Senior Year

Course		*Credit Hours*
HS 4570 Field Training Proposal	....	1
HS 4571-2-3 Senior Externship	....	12
HS 4665 Case Studies	....	3
HS 4693 Seminar	....	1
ISYE 4101 Operations Planning	....	4
PSY 3303[2] General Psychology	....	3
Elective[8] Health Systems	....	3
Elective[9] Approved	....	15
Elective[6] Free	....	3
Senior-year Total	....	45
Total Degree Requirements	....	201

[1]These courses apply toward satisfaction of the eighteen-hour humanities requirement stated in "Information for Undergraduate Students."
[2]These courses apply toward satisfaction of the eighteen-hour social science requirement stated in "Information for Undergraduate Students."
[3]Either POL 1251 or 3200 gives exemption from the U.S. and Georgia constitution examination and any one of HIST 1001, 1002, 3010 or 3011 gives exemption from the U.S. and Georgia history examination. Students electing the examinations must substitute six hours of approved social science electives.
[4]Approved humanities courses are listed in "Information for Undergraduate Students." The eighteen hours of humanities must include ENGL 1001, 1002, and one other English course from the approved humanities list. The student should plan this and other electives with a view toward satisfying the rising junior English examination.
[5]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[6]A list of recommended electives is available upon request. Free elective hours may include credit for PE and/or ROTC courses up to the maximums stated in "Information for Undergraduate Students."
[7]Check the official school bulletin board for the quarters in which senior-year courses are expected to be offered.
[8]The student may choose any course with the HS prefix or a substitute course approved by the faculty.
[9]These courses must be selected from a faculty-approved list, and the set of selections must be approved by the student's advisor.

Health Planning Option

The health planning option is provided in order to broaden the preparation of the health systems specialist for professional practice in the subspecialty of health systems planning. Such a planning function covers manpower, facilities, logistics, organization, finances, and other system components. It includes consideration of medical, behavioral, socioeconomic, demographic, ethnic, political, legal, and other environmental factors. Some health systems planners serve in government agencies, consulting firms, or other organizations concerned with multi-institutional and community-wide systems of health care delivery. Others perform planning functions within management engineering departments of individual hospitals, clinics, or other health care institutions.

Health systems majors may emphasize health systems planning by utilizing their electives to include courses appropriate to the planning function. Such students should make their selections from the following categories:

Course	*Credit Hours*
Health Systems Elective:	
HS 3341	3
Social Science Elective:	
SOC 1376	3
Approved Electives:	
HS 3332	3
HS 3780	3
HS 4021	3
ISYE 4028, 4044, or ICS 4334	3
ISYE 4053, 4056, or 4157	3
Free Electives:	
CP 1100	3
ECON 3501, 4310, 4330, or 4331	3
MGT 4290 or POL 3250	3
POL 3217, 3220, 3221, or 4250	3
SOC 3310	3
Total	36

Premedical Option

The premedical option was designed to satisfy the normal course preparation required by most medical and dental schools while providing the systems orientation now being favored by leading medical educators.

Nationally, about two of every three medical school applicants are rejected and the proportion for professed premeds still in undergraduate school is even higher. A significant advantage of this premedical option is that if the student decides not to apply to medical or dental school or applies and is not admitted, he or she will be prepared to pursue an alternative health career.

Under this premedical option, health systems majors satisfy all required courses of the B.S.H.S. curriculum and utilize their electives to include the key premed courses.

Thus, the graduate is fully qualified as a health systems specialist and is prepared for medical or dental school.

This option concentrates the premed courses in the freshman and sophomore years so as to gain the advantage of submitting the medical or dental school application early in the junior year. Therefore, a decision to elect this option should be made prior to or early in the freshman year.

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1111-21 General Chemistry	5	5	....
CHEM 2113 Chemical Principles	....	....	4
EGR 1170 Engineering Graphics	3	....	....
ENGL 1001-2-3[2] Analysis of Literature	3	3	3
HS 1000 Overview of Health Systems	1	....	....
HS 2011 The Health Field	....	....	3
ICS 1700 Computer Programming	....	3	....
Math 1307-8-9 Calculus I, II, III	5	5	5
Elective English Humanity[8]	....	....	3
Elective[3] Physical Education	1	1	2
Totals	18	17	17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
BIOL 2210-1-2 Principles of Biology	5	5	5
CHEM 3311-2-3 Organic Chemistry	3	3	3
CHEM 3381-2 Organic Chemistry Lab	....	2	2
ISYE 3027 Applications of Probability	....	3	....
ISYE 3028 Engineering Statistics I	....	....	3
MATH 2307 Calculus IV	5	....	....
PHYS 2121-2-3 Engineering Physics	5	5	5
Totals	18	18	18

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ECON 2000-1[4] Economic Principles	....	3	3
ENGL 3023 Written Communications	....	3	....
HS 3011 Hospital Functions	3	....	....
HS 3021 Nonhospital Components	....	3	....
HS 3115-6 Management Engineering I, II	4	3	....
HS 3117-8 Management Engineering III, IV	....	3	3
HS 3211 Data Processing	....	....	3
HS 3351 Projects and Reports	....	....	3
ISYE 3029 Engineering Statistics II	3	....	....
MGT 2000-1 Accounting I, II	3	3	....
MGT 3060 Finance	....	....	3
PSY 3303[4] General Psychology A	3	....	....
Elective[5] Free	....	....	1
Totals	16	18	16

Senior Year[6]

Course	*Credit Hours*
HS 4570 Field Training Proposal	1
HS 4571-2-3 Senior Externship	12
HS 4665 Case Studies	3
HS 4693 Seminar	1
ISYE 3025 Engineering Economy	3
ISYE 3131 Operations Research	3
ISYE 4101 Operations Planning	4
POL 3200[4] American Constitutional Problems[7]	3
PSY 3304[4] General Psychology B	3
Elective: HIST 3010 or 1[4] History of the U.S.[7]	3
Electives[2] Humanities	9
Senior-year Total	45
Total Degree Requirements	201

[1]The CHEM 1111-2, 2113 series is designed for students with good preparation in high school chemistry. It is recommended that students in doubt start with the CHEM 1101-2 series and switch to CHEM 1112 or to 2113 if good grades are made in CHEM 1101-2.
[2]These courses apply toward satisfaction of the eighteen-hour humanities requirement stated in "Information for Undergraduate Students."
[3]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[4]These courses apply toward satisfaction of the eighteen-hour social science requirement stated in "Information for Undergraduate Students."
[5]A list of recommended electives is available upon request. Free elective hours may include credit for PE and/or ROTC courses up to the maximums stated in "Information for Undergraduate Students."
[6]Check the official school bulletin board for the quarters in which senior-year courses are expected to be offered.
[7]Any one of HIST 1001, 1002, 3010, or 3011 gives exemption from the U.S. and Georgia history examination and either POL 1251 or 3200 gives exemption from the U.S. and Georgia constitution examination. Students electing the examinations must substitute six hours of approved social science electives.
[8]Approved humanities courses are listed in "Information for Undergraduate Students." The eighteen hours of humanities must include ENGL 1001, 1002, and one other English course from the approved humanities list. The student should plan this and other electives with a view toward satisfying the rising junior English examination.

School of Industrial and Systems Engineering

Director—Michael E. Thomas, Frank F. Groseclose (Emeritus); *Associate Director for Undergraduate Programs*—Nelson K. Rogers; *Associate Director for Graduate Programs*—William W. Hines; *Professors*—Mokhtar S. Bazaraa, Leslie G. Callahan, Stuart J. Deutsch, Paul T. Eaton (Emeritus), Augustine O. Esogbue, David E. Fyffe, John J. Jarvis, Robert G. Jeroslow (Adjunct), Cecil G. Johnson, Lynwood A. Johnson, Patrick D. Krolak, Robert N. Lehrer, Douglas C. Montgomery, H. Donald Ratliff, William B. Rouse, C. M. Shetty, Matthew J. Sobel (Adjunct), Rocker T. Staton (Emeritus), Gerald J. Thuesen, Harrison M. Wadsworth, Jr., John A. White, Jr; *Associate Professors*—Jerry Banks, Terence Connolly, Willard R. Fey, Russell G. Heikes, Leon F. McGinnis, Robert G. Parker, Alan B. Young; *Assistant Professors*—Faiz A. Al-Khayyal, John J. Bartholdi III, John S. Carson II, Yahya Fathi, John M. Hammer, Michael L. Pinedo, Loren K. Platzman, Craig A. Tovey; *Lecturers*—Edward H. Ely, Thomas L. Sadosky.

General Information

Industrial and systems engineering provides both a basic engineering foundation and a grounding in the interactions between technology and management. Students in the program are usually interested in obtaining a fundamental engineering background as the basis for professional specialization in activities associated with the field-operations research, management science, systems engineering, methods, organization, planning—or as preparation for other endeavors, such as management or as a foundation for law, medicine, or other pursuits. The study of industrial and systems engineering places emphasis upon developing the student's abilities to analyze and design systems that integrate technical, economic, and social behavioral factors in industrial, service, social, and government organizations. The degree program offered is the Bachelor of Industrial Engineering (B.I.E.)

B.I.E.

The principal strength of the program leading to the Bachelor of Industrial Engineering degree lies in a solid, well-coordinated core of courses in systems analysis and systems design, which relies heavily upon the engineering sciences, basic sciences, and social sciences. Elective hours make the program flexible as does the senior year design sequence, which permits a student to gain experience in design activities in manufacturing, service, or government industries. The broad spectrum of required course work associated with the design sequence qualifies the student to perform in operations and facilities, management information and controls, and systems engineering environments.

Options for Exceptional Students

An option program is available to encourage students with superior abilities to fully avail themselves of a range of unusual educational opportunities.

Participation in these programs requires demonstrated scholastic excellence, prior arrangements with the student's advisor and provides the following options, individually or in combination.

Graduate level courses in lieu of senior year electives

Students with a cumulative grade-point average of 3.3 or above may schedule up to nine credit hours of approved graduate level courses. These credits, when approved by the student's advisor, may be made available for subsequent credit toward a graduate degree.

Accelerated study

Students with a 3.3 or above average during the three preceding quarters (including at least forty-five credits), may complete course requirements for any nonproject industrial and systems engineering course at their own pace by self study with counseling and guidance by the course instructor. Students may register for any number of courses but must satisfy instructor and course examination requirements. Class attendance is not required. Arrangements must be made with course instructors prior to the start of the quarter.

Individual project and research work

Students with a 3.0 or above average during the preceding three quarters (including at least forty-five credits) may schedule up to twelve credits of project or research work or both, done in collaboration with the faculty or advanced graduate students, which may be substituted for senior-year electives. Students with less than a 3.0 average are limited to six credits of such project or research work.

Governor's intern program
ISYE seniors enrolled in the governor's intern program may receive six hours of design credit (4104-5) and six hours of ISYE elective credit for participation in the program.

Visiting Scholar/Practitioner Offerings

Upon occasion, the school brings to campus selected individuals of unique accomplishment for course offerings built around their special areas of activity, thus making available a broader range of course materials than regularly provided. The typical schedule is Friday afternoon and evening instruction four times during the quarter.

Graduate Programs

The School of Industrial and Systems Engineering offers graduate programs leading to the degrees Master of Science in Industrial Engineering, Master of Science, Master of Science in Operations Research, and Doctor of Philosophy.

The M.S.I.E. program is available for students holding the B.I.E. degree and for other engineers who satisfy requisites covering the principal subject matter of the current B.I.E. curriculum. The M.S.O.R. program is available for students holding the B.S. in engineering, mathematics, or science. Requisites include work in probability, statistics, engineering economy, linear algebra, advanced calculus, and optimization. These requirements may be satisfied after enrollment; however, such course work may not be applied to satisfy degree requirements.

The undesignated M.S. is intended for those students who desire to follow programs in applied statistics, systems analysis, industrialization, or other special programs. Prerequisites are the same as for the M.S.O.R. program.

Except for the industrialization and systems analysis programs, a student has two options: either thirty-three quarter hours of course work and a thesis or fifty quarter hours of course work and a written comprehensive examination. The industrialization program requires forty-three quarter hours of course work and a thesis, and the systems analysis program requires thirty-three quarter hours of coursework and a thesis.

The doctoral program is intended for highly gifted individuals for whom past accomplishments and evaluation indicate a high potential for successful completion of the program requirements and a subsequent creative contribution to the field. Admission is, therefore, dependent upon student qualification rather than educational background in any specified discipline.

All degree curricula of the school are offered on a twelve-month basis. Graduate programs may be started in any quarter.

Financial aid is available in the form of traineeships, fellowships, and research assistantships.

The B.I.E. Curriculum

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ENGL 1001-2-3[6] Introduction to Literature	3-0-3	3-0-3	3-0-3
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design I	2-3-3	....	....
Elective[4] Engineering	....	X-X-3	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
Electives[1] Physical Education	X-X-2	X-X-1	X-X-1
Electives[2] Social Science	....	....	3-0-3
Totals	X-X-18	X-X-17	X-X-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
ESM 2201 Statics	....	....	3-0-3
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
Electives[3] Humanities	3-0-3	3-0-3	3-0-3
ECON 2000-1 Principles of Economics	3-0-3	3-0-3	....
MGT 3700[5] Analysis of Financial Data	....	....	4-0-4
ICS 1700 Digital Computer Organization and Programming	....	3-0-3	....
ISYE 3027 Applications of Probability	....	....	3-0-3
MATH 3709 Math for Systems Engineering	....	....	3-0-3
Elective[2] Social Science	3-0-3	....	....
Totals	18-3-19	18-3-19	16-0-16

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ESM 3201 Dynamics I	3-0-3	....	....
ESM 3301 Mechanics of Deformable Bodies	....	5-0-5	....
ME 3720 Thermodynamics	....	....	4-0-4
ISYE 3028-9 Engineering Statistics I, II	3-0-3	3-0-3	....
ISYE 3105 Organizational Structures	3-0-3	....	....
ISYE 3025 Engineering Economy	3-0-3	....	....
ISYE 3010 Man-Machine Systems	....	3-0-3	....
ISYE 3115 Industrial and Systems Engineering Measurements	....	....	3-0-3
ISYE 3260 Introduction to Systems Engineering	3-0-3	....	....
ISYE 3131-2 Operations Research I, II	....	3-0-3	3-0-3
ISYE 4044 Simulation	....	....	2-3-3
ISYE 3100 The Professional Practice of Industrial and Systems Engineering	....	....	0-3-1
ENGL 3015 Public Speaking	3-0-3	....	....
ENGL 3023 Written Communication in Science, Business and Industry	....	3-0-3	....
Elective Free	....	....	3-0-3
Totals	18-0-18	17-0-17	15-6-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
EE 3700 Elements of Electric Circuits and Instruments	3-0-3	....	....
ISYE 4101 Operational Planning and Scheduling	3-3-4	....	....
ISYE 4102 Operations and Facilities Design	3-3-4	....	....
ISYE 4103 Management Information and Control Systems	....	3-0-3	....
ISYE 4104-5 ISYE Design I, II	....	0-9-3	0-9-3

ISYE 4039			
Quality Control	3-0-3	....	....
Electives			
ISYE	....	6-0-6	6-0-6
Electives[2]			
Social Science	....	3-0-3	3-0-3
Electives			
Free	3-0-3	....	3-0-3
Totals	15-6-17	12-9-15	12-9-15

[1]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[2]Social Science electives must include three hours of U.S. History, three hours of U.S. Government, and six credit hours of Social Science.
[3]See "Information for Undergraduate Students" for humanities electives to satisfy the College of Engineering requirements.
[4]See College of Engineering section "Curricula and Courses of Instruction" for freshman engineering electives.
[5]MGT 2000 and MGT 2001 may be substituted for MGT 3700 plus two hours of free electives.
[6]Freshmen who waive English 1001, 1002, or 1003 as a result of English Department Placement Tests may substitute 2000-level or higher English courses which qualify as Humanities.

School of Mechanical Engineering

Established in 1888

Acting Director and Professor—Walter O. Carlson; *Regents' Professors*—Peter Kezios, Allan D. Pierce; *Professors*—John T. Berry, William Z. Black, Gene T. Colwell, Steven L. Dickerson, Pandeli Durbetaki, Jerry H. Ginsberg, Alan V. Larson (Associate Director), Subbiah Ramalingam, Ward O. Winer; *Associate Professors*—Wayne J. Book, Prateen V. Desai, Thomas L. Eddy, Harold L. Johnson, Prasanna V. Kadaba, Samuel V. Shelton; *Assistant Professors*—Joseph A. M. Boulet, Robert B. Evans, Ronald T. Gibbs, James G. Hartley, Sheldon M. Jeter, Larry D. Koffman, William J. Wepfer, Wendell M. Williams, Paul J. Yoder; *Instructor*—Carolyn W. Meyers; *Lecturers*—James W. Brazell, Craig A. Depken, Guy W. Gupton, Kenneth W. Jackson, Harry I. Leon, Robert W. Newman; *Research Engineer*—Scott S. Bair.

General Information

Mechanical engineering traditionally deals with the largest diversity of engineering problems. Because of this general nature, mechanical engineering allows a number of multidisciplinary activities to be conveniently organized within it.

Mechanical engineering embraces the generation, conversion, transmission, and utilization of thermal and mechanical energy, the design and production of tools and machines and their products, the consideration of fundamental characteristics of materials as applied to design, and the synthesis and analysis of mechanical, thermal, and fluid systems, including feedback and control. Design, production, operation, administration, economics, and research are functional aspects of mechanical engineering.

The undergraduate curriculum covers the fundamental aspects of the field, emphasizes basic principles, and educates the student in the use of these principles to reach optimal design solutions for engineering problems. Specific design subject matter and materials are also drawn from such engineering activities as solar energy and biomechanical systems, as well as from the more traditional areas.

Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics. The junior and senior years are devoted to the strength of materials and metallurgy, applied mechanics, heat transfer, fluid mechanics, systems and controls, design, and the application of fundamentals to the diverse problems of mechanical engineering. Laboratory work and design projects are stressed.

Satisfactory completion of the curriculum leads to the degree Bachelor of Mechanical Engineering. All required mathematics courses must be passed with a grade of "C" or better.

Optional Programs

While the curriculum is structured to meet the general educational goals of the majority of mechanical engineering students, the school regularly considers and approves modifications of the basic program to allow a student with certain well-conceived educational objectives to pursue minor fields within the school or within Georgia Tech while earning a degree in mechanical engineering. In this way a student may achieve his or her basic degree in mechanical engineering while specializing in any one of a large number of other fields. The student who follows the regular ME curriculum takes a number of electives as well as special problems and projects, all of which allow latitude in pursuing his or her educational goals and special interests.

School Facilities

The School of Mechanical Engineering has many types of specialized instruments and equipment associated with laboratories for the study of two-phase flow, lubrication and rheology, material processing, fire hazard and combustion, magnetogasdynamics, energetics, fluidics and fluid power control, heat transfer, vibration and thermal stress, computer-aided design, automatic and digital control, machinery noise, plasmas, robotics, and other areas. The school is housed in a four-building classroom-research complex. Part of this complex is a modern classroom-seminar conference building which serves the Institute.

The main research building of the school houses several remote terminals linked to the main campus research and teaching computer. It also has analog and microcomputer facilities. The school research activity is served by its own machine and instrumentation shops with a full-time supporting staff of technicians.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication	2-3-3	....	....
Elective Freshman Engineering Elective[1]	....	X-X-3	....
ME 1001 Introduction to M.E	....	....	1-0-1
Electives[4] Humanities Social Science Modern Language	3-0-3	3-0-3	3-0-3
Electives[5] Physical Education			
Aquatics	X-X-1	....	....
Fitness	....	....	X-X-2
Elective	....	X-X-1	....
Electives[2] Free	2-0-2	2-0-2	2-0-2
Totals	X-X-19	X-X-19	X-X-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 Differential Equations	....	....	5-0-5
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	....	3-0-3
ESM 3301 Mechanics of Deformable Bodies	....	5-0-5	....
ME 2212 Materials Science	....	....	3-0-3
Electives[4] Humanities Social Science Modern Language	3-0-3	3-0-3	6-0-6
Totals	15-3-16	17-3-18	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
ME 3322-3-4 Thermodynamics	3-0-3	3-0-3	3-0-3
ME 3342-3-4 Transport Phenomena I, II, III	3-0-3	3-0-3	3-3-4
EE 3725 Electric Circuits and Fields	2-3-3	....	....
EE 3726 Elementary Electronics	....	2-3-3	....
EE 3727 Electric Power Conversion	....	....	2-3-3
ME 3212 Materials Technology	3-3-4	....	....
ME 3016 ME Computer Applications	....	2-3-3	....
ME 3055 Experimental Methodology	....	....	1-3-2
ME 3113 Kinematics and Dynamics of Linkages	3-0-3	....	....
ME 3114 Dynamics of Machinery	....	....	3-0-3
ME 3181 Machine Elements	....	3-0-3	....
Electives[4] Humanities Social Science Modern Language	....	3-0-3	3-0-3
Totals	14-6-16	16-6-18	15-9-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
ME 4183 Design Theory	3-0-3	....	....
ME 4184 Design Engineering	....	....	0-6-2
ME 4318 Thermal Systems Analysis and Design	....	4-0-4	....
ME 4055 Experimental Engineering	....	....	1-3-2
ME 4344 Transport Phenomena IV	3-0-3	....	....
ME 4212 Material Processes	....	3-3-4	....
ME 4445 Automatic Control	3-0-3	....	....

ISYE 4725 Engineering Economy	3-0-3	....	....
Electives[3]			
Technical	....	3-0-3	6-0-6
Electives[4]			
Humanities Social Science Modern Language	3-0-3	3-0-3	3-0-3
Electives[6]			
ME Design	....	3-0-3	....
Totals	15-0-15	16-3-17	10-9-13

[1]See College of Engineering section "Curricula and Courses of Instruction" for engineering electives.
[2]These free elective courses may be taken at any time during the course of study. If ROTC is elected by the student these six credit hours may be applied for basic ROTC, which should be scheduled beginning the first quarter the student is enrolled.
[3]Nine hours of technical electives chosen from ME 3000, 4000, and 6000 level courses. Graduate courses (6000 level) must have consent of advisor. Courses other than these may be selected from mathematics, physics, chemistry, biology, another field of engineering, or graduate courses.

A student who wishes to take courses not in ME must so notify the director concerning his or her choice and obtain approval at advance registration for the first quarter of his or her senior year. A lab course (2-3-3) may be scheduled in place of a (3-0-3) course. A student completing his or her junior year with a grade average of 2.5 or higher may elect one technical elective from the special problem courses ME 4901 through 4912. (The particular course selected depends on the number of hours of credit needed.) This student will follow a course of individual study under the guidance of a faculty member with the approval of the school director. Nine hours of electives may be replaced by advanced ROTC.
[4]For selection of acceptable courses see list of electives allowed by the College of Engineering in "Information for Undergraduate Students."
[5]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[6]Approved design electives are marked with an asterisk in the list of ME courses.

School of Nuclear Engineering and Health Physics

Established in 1962

Director—L. E. Weaver; *Callaway Professor*—W. M. Stacey, Jr.; *Neely Professor*—M. W. Carter; *Regents' Professor*—G. G. Eichholz, R. W. Carlson (Georgia Power Professor); *Professors*—J. D. Clement, M. V. Davis, D. S. Harmer, B. Kahn, J. M. Kallfelz, R. A. Karam, J. L. Russell, Jr., A. Schneider; *Associate Professors*—R. G. Bateman, Jr., J. L. Carden, Jr. (visiting), J. N. Davidson, J. W. Poston; *Adjunct Associate Professor*—P. H. McGinley.

General Information

Nuclear engineering is the branch of engineering directly concerned with the release, control, and utilization of all types of energy from nuclear sources and its environmental impact. Today nuclear energy is being used in a wide variety of applications from the exploration of outer space and the powering of human heart pacemakers to the generation of electricity. With the limited supply of fossil fuels and the growing concern about their environmental effect, the need for nuclear power to produce the large amounts of energy demanded by our society becomes more and more pressing. The School of Nuclear Engineering and Health Physics is playing a vital role in educating the technical manpower required to meet this need.

In addition to the Bachelor of Nuclear Engineering degree, the school administers the program leading to the Bachelor of Science degree in Health Physics. Health physics is an applied science concerned with the protection of man and the environment from the hazards of radiation and chemical pollutants. Typical activities of health physicists today are: development of sound philosophy and principles of radiation protection; practical application of these principles on the job in an industrial or medical setting or with a regulatory agency; and devising new methods and instrumentation for the protection of individual workers and the general public.

Undergraduate Programs

The curriculum leading to the degree Bachelor of Nuclear Engineering is structured to meet the needs of both the student who contemplates employment immediately after graduation and the student planning to pursue graduate study. It has been tailored to provide maximum flexibility in the form of options for each student to develop his or her unique interests or capabilities. These options are built upon the core curriculum covering the basic principles of nuclear engineering: nuclear reactor core design, nuclear fuel design, reactor controls engineering, nuclear fuel process engineering, nuclear power economics, and reactor operations.

Studies for the Bachelor's Degree in Health Physics may lead to careers in radiation protection or environmental surveillance, or may be preparatory to further study at the graduate level for a professional career as a health physicist. The program also provides an excellent premedical education. In addition to the Institute's academic requirements for graduation with a bachelor's degree, the number of quality points earned in nuclear engineering courses taken toward the B.N.E degree or B.S.H.P degree must be at least twice the number of credit hours in those courses. Further, students in the B.N.E degree program must obtain twice the number of quality points as credit hours for courses taken in thermodynamics and transport phenomena.

Program for the Bachelor of Nuclear Engineering

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design	....	2-3-3	....
EE 1010[3] Computer Programming and Graphics	....	....	2-3-3
Elective[1] Engineering	2-3-3	....	....
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[5] Physical Education	0-4-1	2-2-2	0-4-1
Totals	14-10-17	16-8-18	14-10-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 Ordinary Differential Equations	....	....	5-0-5
ESM 2201 Statics	....	3-0-3	....
ESM 3201 Dynamics	....	....	3-0-3
ISYE 4725[3] Engineering Economy	....	....	3-0-3
Electives[2] Free	3-0-3	2-0-2	3-0-3
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	15-3-16	17-3-18	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
PHYS 3001 Modern and Nuclear Physics	5-0-5	....	....
NE 3211 Elements of Nuclear Engineering	3-0-3	....	....
NE 4201-2 Nuclear Reactor Physics I and II	....	3-0-3	3-0-3
HP 4412 Principles of Health Physics	....	3-0-3	....
NE 3110 Radiation Detection	....	....	2-6-4
ESM 3301 Mechanics of Deformable Bodies	....	....	5-0-5

ME 3322-3 Thermodynamics	3-0-3	3-0-3	....
CHE 3300-1[3] Transport Phenomena	....	3-0-3	3-0-3
CHE 3302[3] Transport Phenomena Laboratory	....	....	0-3-1
MATH 4582 Advanced Engineering Mathematics	3-0-3	....	....
MATH 4581[3] Advanced Engineering Mathematics	....	3-0-3	....
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	17-0-17	18-0-18	16-9-19

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
NE 4211-2 Reactor Engineering I and II	3-0-3	3-0-3	....
NE 4230 Nuclear Engineering Design	....	....	2-6-4
NE 4205 Reactor Laboratory	1-6-3	....	....
NE 4001-2-3 Nuclear Engineering Seminar	1-0-1	1-0-1	1-0-1
NE 4260 Radiation Transport and Shielding	....	3-0-3	....
MET 4403[3] Introductory Nuclear Metallurgy	....	3-3-4	....
CHE 3303[3] Transport Phenomena Laboratory	0-3-1	....	....
EE 3725 Electric Circuits and Fields	....	....	2-3-3
Electives[6] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[4] Technical	6-0-6	3-0-3	3-0-3
Electives[2] Free	....	....	3-0-3
Totals	14-9-17	16-3-17	14-9-17

[1]For selection of College of Engineering approved elective courses and requirements see "Curricula and Courses of Instruction." EE 1010 cannot be used as a substitution.
[2]Free elective courses may be taken at any time during the course of study. If ROTC is elected by the student, six credit hours may be applied for basic ROTC and a maximum of five credit hours for advanced ROTC. (A maximum of nine credit hours of electives may be used for advanced ROTC-five hours free electives and four hours technical electives).
[3]Other courses may be substituted for these required courses. Substitutions are available from the general office of the School of Nuclear Engineering and Health Physics.
[4]The electives will be selected by the student after consultation with his or her advisor. At least ten credit hours must be in the areas of design, synthessm, and systems. A maximum of four credit hours of technical electives may be used for advanced ROTC.
[5]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[6]See Humanities and Social Sciences Requirements in "Information for Undergraduate Students."

Program for Bachelor of Science in Health Physics

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
PHYS 2121 Particle Dynamics	....	....	4-3-5
MATH 1307-8-9 Calculus, I, II, III	5-0-5	5-0-5	5-0-5
EGR 1170 Visual Communication and Engineering Design	....	2-3-3	....
Elective[1] Technical	2-3-3	....	....

Course	1st Q.	2nd Q.	3rd Q.
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective[3] Physical Education	0-4-1	2-2-2	0-4-1
Elective[4] Free	....	....	3-0-3
Totals	14-10-17	16-8-18	15-7-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 2122 Electromagnetism	4-3-5	....	....
PHYS 2123 Optics and Modern Physics	....	4-3-5	....
MATH 2307 Calculus IV	5-0-5	....	....
MATH 2308 Calculus and Linear Algebra	....	5-0-5	....
MATH 2309 Ordinary Differential Equations	....	....	5-0-5
BIOL 2210-1 Principles of Biology	4-3-5	4-3-5	....
EE 1010 Computer Programming and Graphics	....	....	2-3-3
HP 2401-2-3 Introduction to Health Physics	1-0-1	1-0-1	1-0-1
Electives[4] Free	....	....	6-0-6
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	17-6-19	17-6-19	17-3-18

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 3001 Introduction to Modern Physics	5-0-5	....	....
PHYS 3211 Electronics	3-0-3	....	....
NE 3110 Nuclear Radiation Detection	....	....	2-6-4
HP 4411-2-3 Radiation and Health Physics	3-3-4	3-0-3	3-3-4
MATH 4582 Advanced Engineering Mathematics	3-0-3	....	....
BIOL 3335 General Ecology	3-0-3	....	....
BIOL 4915/6730 Introduction to Radiation Biology	....	....	3-3-4
BIOL 3333[5] Biostatistics	....	3-3-4	....
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[6] Technical	....	....	3-0-3
Totals	17-3-18	14-9-17	14-12-18

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
NE 4001-2-3 Nuclear Engineering Seminar	1-0-1	1-0-1	1-0-1
CHEM 4701 Chemistry of Nuclear Technology	....	3-3-4	....
PHYS 4211 Electronic Instruments	....	2-3-3	....
NE 4260 Radiation Shielding	....	3-0-3	....
HP 4401-2-3 Health Physics Seminar	1-0-1	1-0-1	1-0-1
HP 4440 Non-ionizing Radiation	3-0-3	....	....

NE 4701-2-3 Nuclear Reactor Engineering	3-0-3	3-0-3	3-0-3
NE 4903 Special Problem in Health Physics	....	....	0-9-3
Electives[2] Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[4] Free	6-0-6	....	3-0-3
Elective[6] Technical	....	....	3-0-3
Totals	17-0-17	16-6-18	14-9-17

[1]For selection of approved elective courses, see Freshman Engineering Electives in "Curricula and Courses of Instruction," College of Engineering. EE 1010 cannot be used as a substitution.
[2]See Humanities and Social Sciences Requirements in "Information for Undergraduate Students."
[3]See Department of Physical Education and Recreation in "Curricula and Courses of Instruction."
[4]If ROTC is elected by the student, a maximum of six credit hours of basic ROTC and nine credit hours of advanced ROTC may be counted as free elective hours
[5]Other courses in statistics or data analysis may be substituted. A list of these courses is available in the general office of the School of Nuclear Engineering.
[6]Technical electives will be selected by the student after consultation with his or her advisor.

Facilities

The facilities available on the Georgia Tech campus for instruction and research in nuclear engineering include the following: a 5-megawatt research reactor, a lowpower training reactor, a sub-critical assembly, a 100,000 curie cobalt-60 source, several small digital computers, a CDC CYBER 170/130 and 170/760 computer, hot cells for handling radioactive materials, a complete nuclear instrumentation laboratory, and facilities for analyzing environmental samples by nuclear techniques.

School of Textile Engineering

Established in 1899

Director—Albin F. Turbak; *Callaway Professor*—John L. Lundberg; *Professors*—Winston C. Boteler, Walter C. Carter, W. Denney Freeston, Wayne C. Tincher; *Associate Professors*—Wallace W. Carr, Fred L. Cook, L. Howard Olson, Agaram S. Abhiraman; *Instructors*—Paul E. Hilley, McCamie F. Davis.

General Information

Textiles, one of man's oldest commercial ventures, continues to find new applications in the modern world. Fiber assemblies have many varied uses in our everyday life and are playing critical roles in new complex systems in space, medicine, safety, environmental control, transportation, and construction.

Textile engineering encompasses the synthesis of polymers by nature and man, fiber fabrication processes, assembling of fibers into one-, two- and three-dimensional structures, modification of structural properties through dyeing, finishing, and coating, and measurement of complex aesthetic and mechanical properties of fiberbased systems. New polymers and fibers, new methods of assembling fibers into useful products, and new applications of fibers are being developed continually.

The School of Textile Engineering prepares students for rewarding careers in the polymer-fiber-textile industry. Graduates have positions in manufacturing supervision, technical service, sales, product and process development, research, quality control, and corporate management. They participate in the design, development, manufacturing, and marketing of a broad range of fiber-based and associated products. Many hold key management decision-making positions at a young age.

The textile industry is by far the largest manufacturing industry and employer in the Southeast. If apparel and other associated segments of the industry are included, the textile-based industry is the largest in the United States, representing one out of every eight manufacturing jobs. This is more than five times the number employed in the automobile industry. The textile industry's needs for textile graduates each year far exceed the number of graduates.

Curricula

Three study programs are available leading to the degrees Bachelor of Textile Engineering, Bachelor of Science in Textile Chemistry, and Bachelor of Science in Textiles. Each degree may be pursued in a regular four-year program or the five-year cooperative plan.

A broad background is stressed because of the multidisciplinary nature of textiles. Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics, and in the junior and senior years on materials science, polymer and textile chemistry, applied mechanics, business administration, and application of each field to the broad range of problems encountered in textiles. All three programs provide for student selection of a number of courses from a wide range of general and technical electives.

In place of the many conventional laboratory sessions, textile students participate in a student operated and managed business venture. Students design, develop, produce, and market novelty textile products. Every participant is exposed to all facets of the business environment.

Since most of the textile course work is concentrated in the last two years of the programs, students from junior colleges and community colleges can readily transfer into selected programs of the School of Textile Engineering.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the number of quality points earned in textile courses taken toward the degree must be at least twice the number of credit hours in those courses.

The School of Textile Engineering is housed in the Hightower Building, a four-story classroom and laboratory facility. The building contains equipment illustrating most major types of textile processing. Well equipped laboratories are also available for the chemical and physical characterization of polymers, fibers, and fiber assemblies. Specialized equipment is available for fabric flammability studies, polymer environmental stability experiments, fiber-reinforced composite testing, and energy conservation and water pollution studies. Machine shop and instrumentation facilities with full-time supporting technicians are housed within the building.

Textiles For Other Majors

Students with other majors often enter the textile industry. To further their careers, the School of Textile Engineering has developed coordinated course offerings that will be helpful to students with this goal. Listings of recommended course sequences in textiles are available in the School of Textile Engineering office.

Program for Bachelor of Textile Engineering Degree

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
EGR 1170 Visual Communication and Engineering Design I	2-3-3	....	....
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
PHYS 2121 Particle Dynamics	....	....	4-3-5
Electives[1] Physical Education	X-X-2	X-X-1	X-X-1
TEX 1100 Introduction to Textile Engineering	....	3-0-3	....
Elective Humanities/Social Science/Modern Language	....	....	3-0-3
ICS 2250 Technical Information Resources	....	....	1-0-1
Electives[2]	2-0-2	2-0-2	2-0-2
Totals	X-X-17	X-X-16	X-X-17

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 2201 Statics	3-0-3	....	....
ESM 3201 Dynamics I	....	3-0-3	....
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
PHYS 2122-3 Electromagnetism, Optics and Modern Physics	4-3-5	4-3-5	....
TEX 3400 Computer Applications in Textiles	....	....	2-3-3
TEX 2180 Textile Manufacturing Processes I	0-3-1	....	....

Course	1st Q.	2nd Q.	3rd Q.
TEX 4200 Fiber Science	....	3-0-3	....
ENGL 3023 Written Communication	....	....	3-0-3
Electives Humanities/ Social Science/ Modern Language	3-0-3	3-0-3	3-0-3
Electives[2]	....	....	6-0-6
Totals	15-6-17	18-3-19	14-3-15

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
ESM 3301 Mechanics of Deformable Bodies	5-0-5	....	....
ME 2212 Materials Science	....	3-0-3	....
ME 3720 Thermodynamics	4-0-4	....	....
ISYE 3749 Elementary Quality Control	....	....	3-0-3
TEX 4751 Polymer Science and Engineering II	....	....	3-0-3
TEX 4305 Chemical Preparation and Finishing of Textiles	....	....	3-0-3
TEX 4201-2-3 Mechanics of Fibrous Structures I, II, III	3-0-3	3-0-3	3-0-3
TEX 3600 Elementary Heat and Mass Transfer	....	3-3-4	....
TEX 2181-2 Textile Manufacturing Processes II, III	0-3-1	0-3-1	....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2]	....	3-0-3	3-0-3
Totals	15-3-16	15-6-17	18-0-18

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CE 3053-4 Fluid Mechanics I, II	....	3-0-3	3-3-4
EE 3725 Electrical Circuits and Fields	2-3-3	....	....
EE 3726 Elementary Electronics	....	2-3-3	....
EE 3727 Electric Power Conversion	....	....	2-3-3
TEX 4306 Dyeing and Printing	....	3-3-4	....
TEX 4420 Analysis of Textile Materials	3-3-4	....	....
ISYE 4725 Engineering Economy	....	3-0-3	....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 3480-1 Texile Manufacturing Processes IV, V	0-3-1	0-3-1	....
TEX 3984 Problems in Textile Management II	....	....	0-3-1
TEX 4901[3] Special Problems	....	0-3-1	0-3-1
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives[2]	3-0-3	....	3-0-3
Totals	12-9-15	15-12-19	12-12-16

[1]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[2]Twelve hours of electives must be approved by the department. Six must be humanities/social science/modern language. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.
[3]TEX 4481-2 can be substituted for TEX 4900-1.

Program for the Bachelor of Science in Textiles Degree

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2 General Chemistry	4-3-5	4-3-5	....
ENGL 1001-2-3 Analysis of Literature	3-0-3	3-0-3	3-0-3
MATH 1711-2-3 Mathematics for Management I, II, III	5-0-5	5-0-5	5-0-5
TEX 1100 Introduction to Textile Engineering	....	3-0-3	....
TEX 2103 Yarn Processing	....	....	3-0-3
ICS 2250 Technical Information Resources	....	....	1-0-1
Electives[1] Physical Education	X-X-2	X-X-1	X-X-1
Electives[2]	2-0-2	2-0-2	2-0-2
Totals	X-X-17	X-X-19	X-X-15

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
PHYS 211 1-2-3 Physics	4-0-4	4-0-4	4-0-4
ENGL 3023 Written Communication	....	....	3-0-3
ECON 2000-1 Economic Principles and Problems	....	3-0-3	3-0-3
EGR 1170 Introduction to Visual Communications and Engineering Design I	2-3-3	....	....
TEX 2104 Yarn Processing II	3-0-3	....	....
TEX 3110 Woven Structures I	....	3-0-3	....
TEX 3112 Knit Fabrics	....	....	3-0-3
TEX 2180-1-2 Textile Manufacturing Processes I, II, III	0-3-1	0-3-1	0-3-1
Electives[2]	6-0-6	6-0-6	3-0-3
Totals	15-6-17	16-3-17	16-3-17

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
TEX 3122 Structures of Organic Polymers	3-0-3	....	....
TEX 4305 Chemical Preparation and Finishing of Textiles	....	3-0-3	....
TEX 4306 Dyeing and Printing	....	....	3-3-4
TEX 3113 Nonwoven Fabrics	3-0-3	....	....
TEX 3400 Computer Applications in Textiles	....	....	2-3-3
MGT 2000-1 Accounting I, II	3-0-3	3-0-3	....
MGT 3060 Financial Management	....	....	3-0-3
MGT 3300 Marketing I	3-0-3	....	....
TEX 4200 Fiber Science	....	3-0-3	....
ISYE 3749 Elementary Quality Control	....	....	3-0-3
TEX 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
TEX 3483-4 Problems in Textile Management I, II	0-3-1	0-3-1	....
Electives[2]	3-0-3	6-0-6	3-0-3
Totals	15-6-17	15-6-17	14-9-17

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
TEX 4420 Analysis of Textile Materials	3-3-4	....	....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1

Course	1st Q.	2nd Q.	3rd Q.
TEX 4100 Textile Management Decision-Making	....	2-3-3	....
TEX 4101 Planning and Control in Textile Production Systems	....	....	3-0-3
PSY 4401 Industrial Psychology	....	....	3-0-3
MGT 4200 Industrial Relations	....	....	3-0-3
ISYE 3115 ISYE Measurements	3-0-3	....	....
MGT 3150 Industrial Management Principles	....	3-0-3	....
TEX 3485 Problems in Textile Management III	0-3-1	....	....
TEX 4480 Problems in Production Supervision	0-3-1	....	....
Elective Either TEX 4481-2, Advanced Problems in Textile Management and Production Innovation or TEX 4900-1, Special Problems	....	0-3-1	0-3-1
Electives[2]	6-0-6	6-0-6	6-0-6
Totals	13-9-16	12-6-14	16-3-17

[1]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation for freshman physical education requirements for both men and women.

[2]Twelve hours of electives must be approved by the department. Twenty-one must be humanities/socials science/modern language electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

Program for Bachelor of Science in Textile Chemistry

Freshman Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 1101-2[1] General Chemistry	4-3-5	4-3-5	....
CHEM 2113 Chemical Principles	....	....	3-3-4
TEX 1100 Introduction to Textile Engineering	....	3-0-3	....
ENGL 1001-2-3 Analysis of Literature	3-0-3	3-0-3	3-0-3
MATH 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
ICS 2250 Technical Information Resources	....	....	1-0-1
Electives[2] Physical Education	X-X-2	X-X-1	X-X-1
Electives[3]	2-0-2	2-0-2	2-0-2
Totals	X-X-17	X-X-19	X-X-16

Sophomore Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
CHEM 3381-2 Organic Chemistry Laboratory	....	0-6-2	0-6-2
MATH 2307-8 Calculus IV, V	5-0-5	5-0-5	....
PHYS 2121 Particle Dynamics	4-3-5	....	....
PHYS 2122 Electromagnetism	....	4-3-5	....
PHYS 2123 Optics and Modern Physics	....	....	4-3-5
ENGL 3023 Written Communication	....	....	3-0-3
EGR 1170 Visual Communication and Engineering Design I	2-3-3	....	....

Course	1st Q.	2nd Q.	3rd Q.
TEX 3400 Computer Applications in Textiles	....	....	2-3-3
Electives[3]	3-0-3	3-0-3	....
Totals	17-6-19	15-9-18	12-12-16

Junior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
CHEM 3412-3 Physical Chemistry	3-0-3	3-0-3	....
CHEM 3481 Physical Chemistry Laboratory	....	0-6-2	....
ISYE 3749 Elementary Quality Control	....	....	3-0-3
TEX 4310[4] Textile Instrumental Analysis	....	....	2-3-3
TEX 3600 Elementary Heat and Mass Transfer	....	3-3-4	....
TEX 4750-1 Polymer Science and Engineering I, II	....	3-0-3	3-0-3
TEX 4200 Fiber Science	3-0-3	....	....
TEX 4300 Chemistry and Chemical Processing of Fibers and Textiles I	....	....	3-0-3
TEX 2180 Textile Manufacturing Processes I	0-3-1	....	....
Electives[3]	9-0-9	6-0-6	3-0-3
Totals	15-3-16	15-9-18	14-3-15

Senior Year

Course	*1st Q.*	*2nd Q.*	*3rd Q.*
TEX 4420 Analysis of Textile Materials	3-3-4	....	....
TEX 4405-6-7 Seminar	1-0-1	1-0-1	1-0-1
TEX 4301 Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	....	....
TEX 4302 Textile Finishing Processes	....	3-0-3	....
TEX 4503 Science of Color	....	3-0-3	....
TEX 4201-2 Mechanics of Fibrous Structures I, II	3-0-3	....	3-0-3
TEX 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
TEX 4900-1[5] Special Problems	....	0-3-1	0-3-1
Electives[3]	3-0-3	6-0-6	12-0-12
Totals	13-6-15	13-6-15	16-6-18

[1]CHEM 1111-2 can be substituted for CHEM 1101-2.
[2]See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.
[3]Fifteen hours of electives must be approved by the department. Twenty-seven hours must be humanities/social science/modern language electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.
[4]CHEM 4201 can be substituted for TEX 4310.
[5]TEX 4480-1 can be substituted for TEX 4900-1.

Appendix 2

COLLEGE OF ENGINEERING

Dean—William M. Sangster; *Associate Dean*—W. Denney Freeston; *Assistants to the Dean*—Carolyn C. Chesnutt, Madelyne Watson; *Director of Special Programs*—Carolyn C. Cannon.

General Information

The College of Engineering comprises eleven degree-granting schools of instruction and research. The ten schools of engineering offer programs of study and research leading to bachelor's, master's, and doctoral degrees, and the School of Health Systems offers programs leading to bachelor's and master's degrees. Certain of these schools also offer programs in one or more subdisciplines or subspecialties. These degree offerings are summarized in the following table.

The programs in engineering are designed to provide a fundamental understanding of the engineering sciences, which are based on mathematics and the natural sciences, and of the basic concepts of the humanities and social sciences; then to furnish an understanding of the manner in which these elements are interwoven in engineering practice. Each curriculum provides enough flexibility through elective course opportunities to permit a certain amount of program individualism, even as basic requirements are met.

Students who wish to study engineering but are undecided as to a specific engineering degree program may, for their freshman year, be classified as Undecided Engineering College (UEC) students. UEC students receive advisement from the Office of the Dean of Engineering. Course Work for Undecided Engineering students will focus in the areas of mathematics, chemistry, physics, humanities, and social science, as does the first year course work for all engineering degree programs.

College of Engineering Degree Programs

	B	M	PhD
Aerospace Engineering	X	X	X
Ceramic Engineering	X	X	X
Chemical Engineering	X	X	X
Metallurgy		X	X
Civil Engineering	X	X	X
Environmental Engineering		X	X
Electrical Engineering	X	X	X
Engineering Science and Mechanics	X	X	X
Health Systems	X	X	
Industrial and Systems Engineering	X	X	X
Operations Research		X	X
Mechanical Engineering	X	X	X
Nuclear Engineering	X	X	X
Health Physics	X	X	X
Textile Engineering	X	X	X
Textile Chemistry	X	X	
Textiles	X	X	

Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives in all curricula in engineering: EGR 1170, AE 1350, CERE 1010, CHE 1110,1750,CE 1503, EE 1010,1011, 1750, ESM 1101, 1750, HS 2011, ISYE 1010, ME 1110, 1750, NE 1100, TEX 1100.

Multidisciplinary Programs in Engineering

In addition to its degree programs, the College of Engineering provides unusual opportunities for specialized study in engineering through its multidisciplinary certificate program offerings. Any student in good standing who is pursuing a degree in one of the eleven schools of the Engineering College, or in one of the other colleges, may so select elective courses and the subjects of special problems or thesis research as to satisfy simultaneously both the requirements of his or her major degree program and the requirements of a specialized multidisciplinary program, provided that the school through which the standard degree is being sought is a participant in that program. Upon graduation, the successful student receives both the degree in the major field of study and a certificate attesting to successful completion of the particular related multidisciplinary program.

The table on page 80 shows both currently available multidisciplinary program offerings and those which are in the planning stage (identified by asterisks), as well as the degree levels of the programs.

General Requirements of Undergraduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating undergraduate student, while as individualized as possible, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) undergraduate multidisciplinary requirements are: (1) the program must relate the student's major area to the given multidisciplinary area; (2) courses must be taken under more than one academic unit; (3) at least four courses and twelve credit hours (not required by name and number in the student's major) must be taken in a coherent program; (4) at least three of those courses and nine credit hours must be at the 3000 level or higher; (5) at least two of those courses and six credit hours must be outside the major field (crosslisted courses may be counted outside the student's major); (6) a grade of C or better must be earned in each course counting toward a multidisciplinary certificate.

Multidisciplinary Programs

Multidisciplinary Program Area	Related Degree Levels		
Acoustical Engineering		M	PhD
Bioengineering	B	M	PhD
Computer Engineering		M	PhD
Energy Engineering	B	M	PhD
Engineering Design		M	PhD
Environmental Studies		M*	PhD*
Manufacturing Systems	B*		
Materials Engineering	B	M	PhD
Mineral Engineering	B	M	PhD
Plastics Engineering	B	M	PhD
Pulp and Paper Engineering	B		
Structures Engineering		M	PhD
Systems Engineering		M*	PhD*
Transportation Engineering		M*	PhD*
Urban Engineering	B		

* = Programs in Planning Stage

AE 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: senior standing.
Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as ESM 4760, ME 4760.

AE 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: AE 4760 or equivalent.
Continuation of AE 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as ESM 4761, ME 4761.

AE 6760. Engineering Acoustics I
3-0-3. Prerequisite: consent of school.
Introductory analytical methods, stochastic processes, the wave equation in a compressible fluid, and problems in the radiation of sound. Also taught as ESM 6760 and ME 6760.

AE 6761. Engineering Acoustics II
3-0-3. Prerequisite: AE 6760.
Sound reflection and refraction, scattering and diffraction, sound radiation, and duct acoustics. Also taught as ESM 6761 and ME 6761.

AE 6762. Engineering Acoustics III
3-0-3. Prerequisite: AE 6761.
Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics. Also taught as ESM 6762 and ME 6762.

AE 6763. Noise Reduction and Control (Industrial Applications)
3-0-3. Prerequisites: AE 4760 or equivalent and 6760.
Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as ESM 6763 and ME 6763.

CHE 4414. Air Pollution Control
3-0-3.
Application of mass transfer principles of the design of pollution control systems utilizing adsorption, absorption, filtration, and precipitation. Other topics are process optimization, fuel pretreatment.
Text: At the level of Work and Warner, *Air Pollution—Its Origin and Control.*

CHE 6613. Technology of Fine Particles
3-0-3. Prerequisite: CHE 3301 or consent of school.
An examination of the properties of finely divided materials. Size, surface, pores are treated in relation to reactivity, absorptivity, catalytic behavior, and process engineering operations.
Text: At the level of Allen, *Particle Size Measurement.*

CE 4148. Application of Microbiology in Environmental Engineering
3-0-3.
Introduction to fundamental and applied microbiological principles in environmental engineering field with emphasis on microbial growth and metabolism in biological processes.

CE 6124. Air Pollution Measurements and Control
3-3-4. Prerequisite: consent of school. Fall quarter.
Analysis of air pollution problems of cities and industries, methods of evaluating the problems. Description, design, and use of air sampling equipment.

EE 4026. Audio Engineering
3-0-3. Prerequisites: EE 3270, 3310.
An introduction to the application of the tools of electrical engineering to the detection, measurement, processing, recording, and reproduction of audio frequency signals. Basic principles of sound. Microphones. Loudspeakers. Power amplifiers. Disk phonograph systems. Magnetic tape systems. Broadcast audio. Audio signal processing. Acoustical instrumentation.

EE 4041. Illumination Engineering
3-0-3. Prerequisites: PHYS 2123, EE 3310.
An introduction to interior and exterior lighting design.Basic topics considered are light, sight, color, photometry, illumination, luminaires, and sources.

EE 4751. Laser Theory and Applications
3-0-3. Prerequisite: PHYS 2123.
Principles of laser operations. Types of lasers. Survey lectures on the applications of lasers to various fields. Course intended for both EE and non-EE majors. Also taught as PHYS 3751.

ESM 6461. Biosolid Mechanics
3-0-3. Prerequisites: ESM 3301 or equivalent, MATH 2309 or equivalent, ESM 4351 or equivalent.
Mechanics as applied to living tissues. Bioviscoelastic solids: The constitutive equations for blood vessels, muscles, cartilage, bone, and other tissues.

HS 6340. Health Planning Techniques
3-0-3. Prerequisites: HS 6001, ISYE 6739.
Methods of group-consensus formation, goal setting and health needs assessment. Coverage includes Delphi and nominal group processes, patient-origin studies, accessibility analysis and decision procedures.

ISYE 3105. Organizational Structures
3-0-3.
The organizational elements, activities, and structures within which an industrial engineer functions.

ISYE 3113. Physiological and Biomechanical Analysis of Work
3-0-3. Prerequisite: ISYE 3010.
Techniques of data collection and analysis for effective man-power oriented tool and work place design.

ISYE 4090. Legal and Ethical Phases of Engineering
3-0-3. Prerequisite: senior standing or consent of school.
Introduces the engineer to the ethical, legal, and professional attitudes to be encountered in the future working environment. Includes business, patent, and copyright law considerations.

ISYE 4103. Management Information and Control Systems
3-0-3. Prerequisites: ISYE 4101.
Principles of the analysis and design of management information and control systems—especially those involving electronic data processing.

ISYE 4725. Engineering Economy
3-0-3. Prerequisite: sophomore standing. Not available to ISYE students or students with credit for ISYE 4726.
Fundamental principles and basic techniques of economic analysis of engineering projects including economic measures of effectiveness, time value of money, cost estimation, breakeven and replacement analysis.

ISYE 6101. Modern Organizations
3-0-3.
A comprehensive study of the theories of industrial organization with particular emphasis on analyzing, evaluating and integrating organizational activities.

ISYE 6103. Organizational Decision-Making
3-0-3. Prerequisites: ISYE 6101, 6734.
A course integrating behavioral findings with mathematical models of the decision process. The major focus is on these processes in organizational settings.

ISYE 6107. Management of Improvement
3-0-3.
Concepts of the management of improvement endeavors, strategies and tactics for achieving continuous improvement within organizations. Theoretical bases and approaches to encourage innovation are studied.

ISYE 6218. Work Systems Design
3-0-3. Prerequisite: consent of school.
Advanced study of the design of work systems with emphasis on the human operator and that role in the work system.

ISYE 6219. Human Factors Engineering
3-0-3.
Application of information on human capabilities and limitations in the design process. Design problems are used to aid understanding of application of human factors data.

ISYE 6220. Work Physiology
3-0-3.
An evaluation of the various factors affecting human physical performance in the industrial environment. Topics: anthropometry, biomechanics, energy expenditure, heat stress, fatigue, training, strength.

ISYE 6221. Man-Machine Control Systems
3-0-3. Prerequisite: consent of school.
An introduction to the application of systems theory and methodology to the analysis and design of man-machine control systems.

ISYE 6225. Advanced Engineering Economy
3-0-3. Prerequisites: ISYE 3025, 3131.
Advanced engineering economy topics, including measuring economic worth, economic optimization under constraints, analysis of economic risk and uncertainty, foundations of utility theory.

ISYE 6739. Experimental Statistics
4-0-4. Prerequisite: MATH 2308.
An introduction to the application of statistics. Topics include probability concepts, sampling distributions, point and interval estimation, hypothesis testing, multiple linear regression, analysis of variance. Not available for degree credit to ISYE students.
Text: at the level of Hines and Montgomery, *Probability and Statistics.*

ME 3734. Environmental Technology in Architecture I
3-0-3. Prerequisite: PHYS 2113 or 2123. Not for ME students.
Needs of modern structures. Water supply and drainage. Fire protection. Environmental comfort. Design heat load calculations. Generation, transport, and distribution of heat with associated costs.

ME 3735. Environmental Technology in Architecture II
2-3-3. Prerequisite: ME 3734. Not for ME students.
Effects of solar energy. Cooling load estimates. Air conditioning systems. Delivery methods. Energy management, conservation, and total energy systems. Latest topics in environmental control.

ME 4186. Biomechanical Design*
3-3-4. Prerequisite: ME 4445 or equivalent.
Design of systems utilizing human operator dynamics in the loop. Biological systems treated as structures, power sources and information systems, operator modeling.

ME 4318. Thermal Systems Analysis and Design
4-0-4. Prerequisites: ME 3324, 4344, 4183; ISYE 4725.
Analysis, design, and optimization of thermal systems and components with examples from such areas as power generation, refrigeration, and propulsion. Energy conservation schemes, total energy systems and their characteristics.

ME 4319. Thermoeconomic Design*
3-0-3. Prerequisite: ME 4318.
Design via synthesis and optimization of systems, components, and subcomponents modeled from thermal phenomena or their direct analogs while considering constraints from cost, size, weight, government regulations, and other such factors.

ME 4321. Principles of Air Conditioning*
3-3-4. Prerequisites: ME 3324, 4344 or consent of school.
Psychrometric principles. Thermal comfort. Load estimates. Environmental control. System design using load wedge and supply area concepts. Experiments to determine components and system performance.

ME 4343. Heating, Ventilating, and Air Conditioning Design*
3-0-3. Prerequisite: ME 4321.
Sizing of equipment for environmental control. Design of transportation and delivery systems. Energy recovery schemes. Total energy concepts and design features.

ME 6332. Heat Transfer I
3-0-3. Prerequisite: ME 4344 or consent of school.
Conduction-steady state and transient, one and multi-dimensional geometries. Emphasis on analytical methods-exact and approximate, on numerical and graphic techniques.

ME 6333. Heat Transfer II
3-0-3. Prerequisite: ME 6332 or consent of school.
Convection-forced and free, in laminar and turbulent, internal and external flows. Analogy between momentum and heat transfer. Scaling laws and partial modeling.

ME 6334. Heat Transfer III
3-0-3. Prerequisite: graduate standing.
Radiation-electrodynamics, radiation optics, photon gas concept, black body radiation, surface characteristic, exchange in enclosures, radiation through continua, experimental methods.

ME 6370. Thermal Environmental Control
3-0-3. Prerequisite: consent of school.
Thermodynamic relations of moist air. Air conditioning processes. Environmental systems for thermal comfort. Direct and indirect contact transport processes.

NE 3110. Nuclear Radiation Detection
2-6-4. Prerequisite: PHYS 3001.
A laboratory introduction to the principles and characteristics of basic detectors for nuclear radiations and the electronic systems associated with them.

HP 4412. Principles of Health Physics
3-0-3. Prerequisite: PHYS 3001 or HP 4411.
Course emphasizes the biophysical basis of radiation protection and the development of protection criteria.

HP 4413. Applied Health Physics
3-3-4. Prerequisite: HP 4412 or consent of school.
Topics covered include personnel monitoring, bioassay, air sampling and respiratory protection, radiation surveys of nuclear reactors, accelerators, and X-ray installations.

HP 4440. Effect of Nonionizing Radiation and Protection Standards
3-0-3. Prerequisites: consent of school and HP 4412 or equivalent.
A study of methods of production and control of exposure to nonionizing radiations and a review of effects of human exposure and of the radiation protection standards.

HP 6800. Industrial Health Protection Survey
3-3-3.
A survey of the major physical and chemical hazards in the industrial environment emphasizing recognition, monitoring technology, engineering control methodology, best practice, and current regulations.

TEX 4480. Problems in Production Supervision
0-3-1. Prerequisites: TEX 2180-1-2, 3480-1.
Supervision of the student operated enterprise production operations. Solving day to day problems in logistics, personnel relations, and manufacturing technology.